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SWITCH DRIVER CONCEPT DEVELOPMENT.(U)

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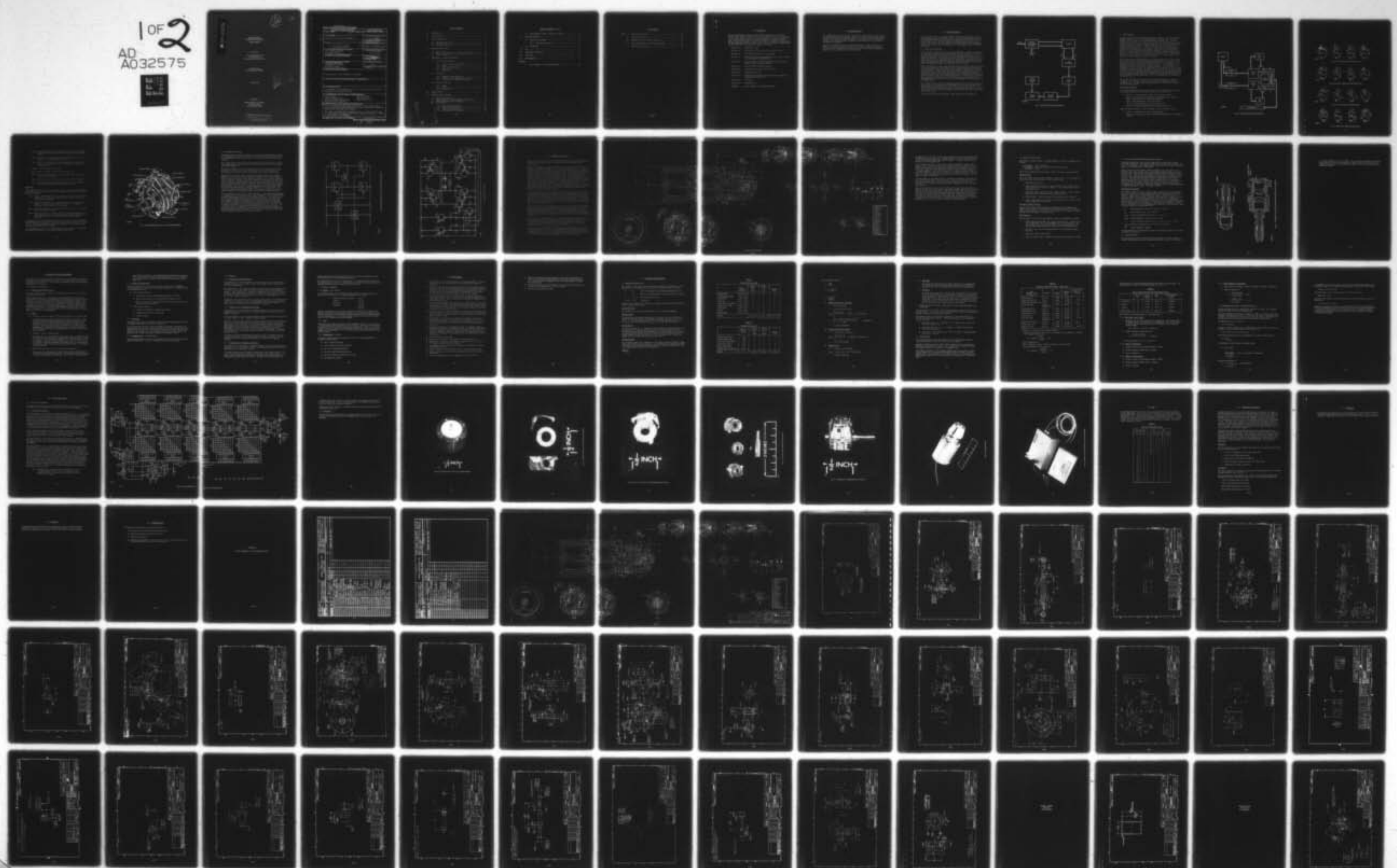

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SWITCH DRIVER
CONCEPT DEVELOPMENT

FINAL REPORT

Prepared by

AVCO SYSTEMS DIVISION
201 Lowell Street
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AVSD-0318-76-RR
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Prepared for

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Mechanical Code Response
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The report describes the design concept of a unique signal switch driver along with program objectives, design requirements, supporting analyses and functional test results.

The report concludes that the design concept is sound and will meet all the design requirements with a 60 Hz response capability. Follow-on development is recommended.

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1.0 INTRODUCTION

This report describes the Switch Driver concept developed by Avco Systems Division under Contract DAAA21-76-C-0203 for Picatinny Arsenal. The effort conducted in this program has included a detailed preliminary design documented on Avco's format layouts, assembly and detail drawings. Extensive functional analysis has been performed to support the design and a complete operating model has been fabricated and functionally tested at 60 Hz, successfully demonstrating concept feasibility. The report is organized as follows:

Section 2.0 - Program Objectives.

Section 3.0 - A description of the Switch Driver design concept.

Section 4.0 - A detailed description of the mechanism.

Section 5.0 - Describes the design requirements and the concept features and characteristics addressing them.

Section 6.0 - Describes design features addressing additional requirements developed during the program.

Section 7.0 - Presents supporting design analyses.

Section 8.0 - A description of the Switch Driver Model.

Section 9.0 - Breadboard Model Code.

Section 10.0 - Describes the functional tests conducted and presents the resulting performance data.

Section 11.0 - Conclusions.

Section 12.0 - Recommendations.

Appendix A - Detail Drawings of the Breadboard Model.

2.0 PROGRAM OBJECTIVE

The program objective is to develop a Switch Driver (SD) mechanism concept which has the inherent fail/safe features required for current nuclear weapons safety criteria. The device incorporates features for enhancing fail/safe functioning through use of multiple stimuli including a coded signal which is maintained throughout the mechanism.

The scope of this effort was to develop and document a design concept which meets the requirements stated in Section 5.0, contains the design features of Section 6.0, and to demonstrate concept feasibility by analyses and laboratory bench tests of a functional model of the device.

3.0 DESIGN DESCRIPTION

The Switch Driver (SD) is a single channel fail safe electromechanical device which provides a safety and arming function. The device must remain safe until a predetermined code has been received and subsequently provide a 90° rotation of the output shaft. The SD is designed to receive electrical power and an optical code, convert the code signal to electrical pulses, then to mechanical pulses which provides the output function. A block diagram of the SD is shown in Figure 1.

3.1 FUNCTIONAL DESCRIPTION

The Switch Driver (SD) consists of an optical/electronic package, electromagnetic dc torque motor (torquer), code mechanism and main shaft as shown in Figure 1. The optical/electronic package receives a two channel complementary optical code signal and converts it to a series of positive and negative electrical signal inputs to the torquer. The torquer converts the positive and negative electrical code sequence to a corresponding series of clockwise and counterclockwise rotations. The main shaft, which is coupled to the torquer through the code mechanism, thus advances as long as the generated code is correct.

After 19 consecutive correct codes have been received, the main shaft has rotated but the output shaft has been inhibited by the clutch mechanism and remains in a locked position. The output shaft is then coupled to the main shaft (through the clutch) when the 20th correct electrical pulse is applied to the torquer. (No rotation of the output shaft has occurred to and including this point). An additional 8 pulses will then incrementally rotate the output shaft 90° where it will be locked in place by the final position lock. In all, 28 electrical codes must be sensed for arming, the first 20 of which must correspond to the preprogrammed mechanical code (the last 8 electrical signals, if desired, could also be a coded word).

In the event that an incorrect complementary optical code is received during the first 20 bits of information, the code mechanism will lock-up and prevent any further motion of the main shaft (abort mode). The unit will thus fail safe. If the code bits are received on both lines or none is received at all (i.e., two "1's" or two "0's") no electrical signal is delivered to the torquer and no main shaft motion occurs.

The SD can be reset from the locked or abort modes without disassembly.

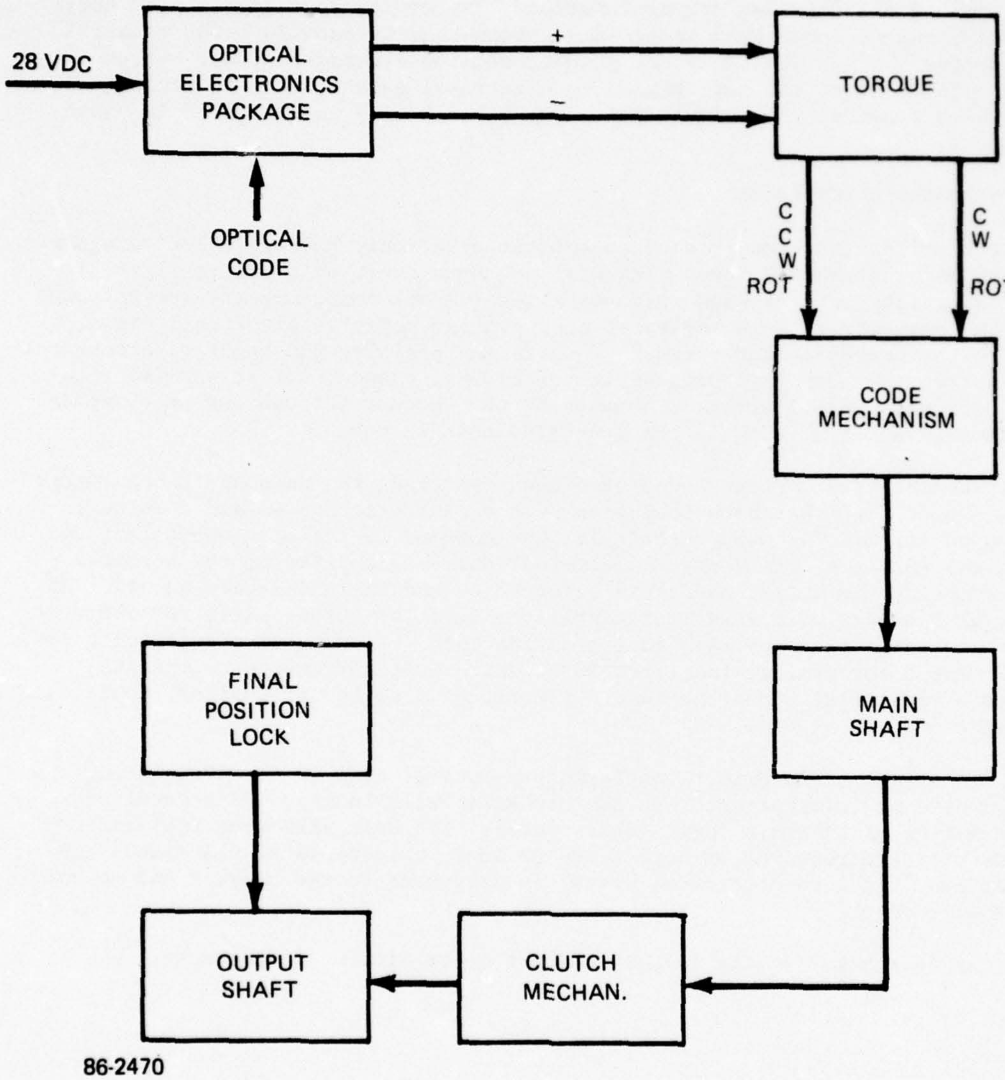

Figure 1 SWITCH DRIVER BLOCK DIAGRAM

3.2 CODE MECHANISM

A block diagram of the code mechanism is shown in Figure 2. The code mechanism primarily consists of a pair of drive mechanisms, two drive pawls, two lock ratchets, two lock arms, a drive ratchet and dual transfer pins. The drive ratchet, which is keyed to the main shaft, has the code machined into the configuration such that a tooth is always presented to one or the other drive pawls. A clockwise rotation (from the torquer) will only actuate Drive Mechanism 1 which will rotate Drive Pawl 1. This will engage the drive ratchet only if a ratchet tooth is available at that location. Conversely, a counterclockwise rotation will only actuate Drive Mechanism 2 which will in turn rotate Drive Pawl 2. A correct code (CW or CCW rotation) therefore, depends on which drive pawl has a tooth presented to it from the drive ratchet. When the drive ratchet receives the correct code, it indexes the main shaft via the key and the lock ratchets via the transfer pins to a new position.

The lock ratchets are configured to have the code machined on the outside face. The code is in the form of a mechanical interference with the lock arm. If the correct drive pawl is actuated, the adjacent lock arm will be cammed to a non-interfering position with the lock ratchet protrusion. No interference is presented to the other lock arm which remains stationary. If an incorrect complementary code is received, the main shaft will not rotate (no tooth will be presented to the drive pawl), the lock arm will not be lifted, the lock ratchets will be rotated into permanent interference with the lock arm, and the unit will be locked up. Thus, with the code being purely mechanical and machined directly into the ratchet configuration prior to machining, it is completely flexible and can be any desired binary combination, (i.e., no constraint on the combination of "0's" of "1's").

The sequence of operation is shown in the functional schematics of Figures 3 through 6. These are plan views of each of the ratchet elements during an operating cycle. The most significant features of the function are explained in the following paragraphs.

<u>Normal Operating Cycle</u>

In a normal operating cycle, the drive ratchet rotates the main shaft through the key and rotates both lock ratchets via the dual transfer pins.

a. Figure 3 -- Initial position (start of each optical code bit).

View A Left lock arm (1) in potential interference with a coded protrusion (dark area) of the left lock ratchet (2).

View B Tooth presented to left drive pawl (3).

View C No tooth presented to right drive pawl (4).

View D No potential interference with right lock arm (5).

This code position dictates a left arm index as shown in Figures 5 and 6.

b. Figure 4 -- Mid-stroke of correct operating cycle.

View A Lock arm (1) is moved to non-interfering position by the camming pin (6).

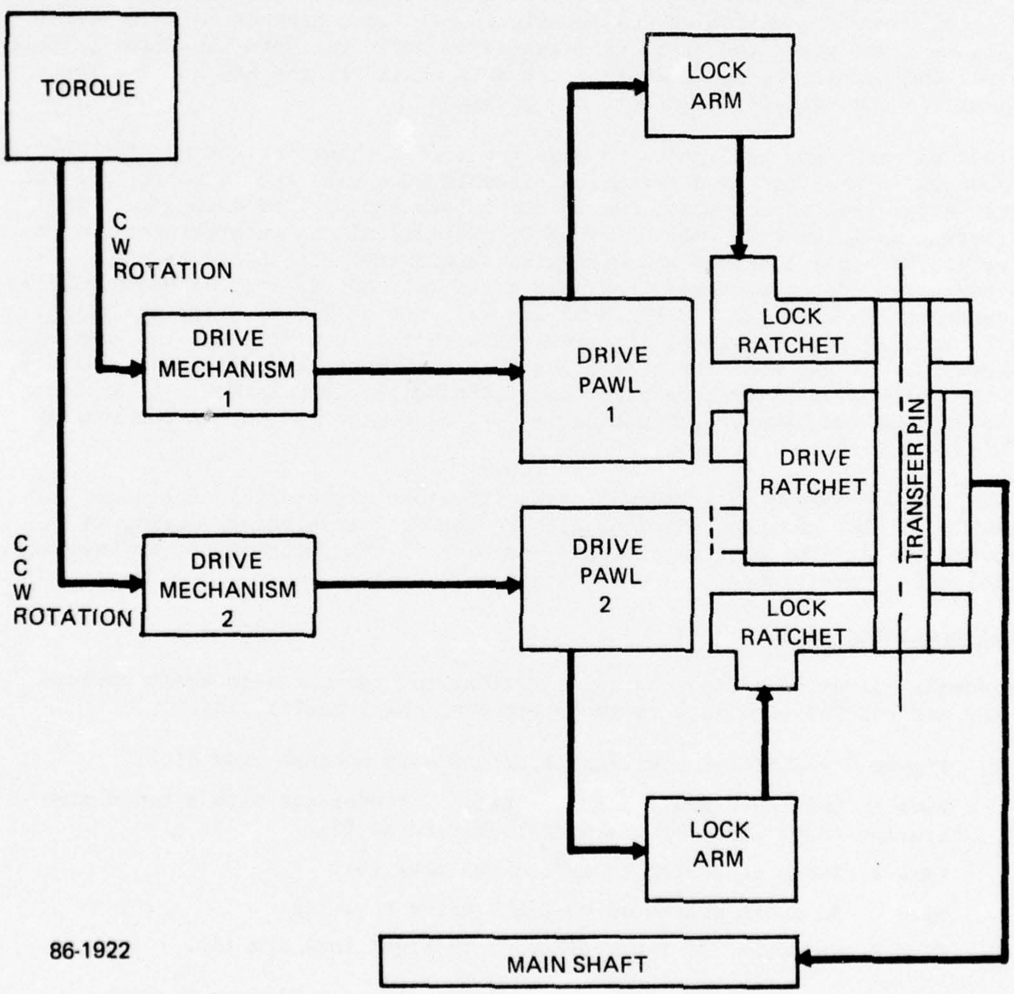

Figure 2 CODE MECHANISM BLOCK DIAGRAM

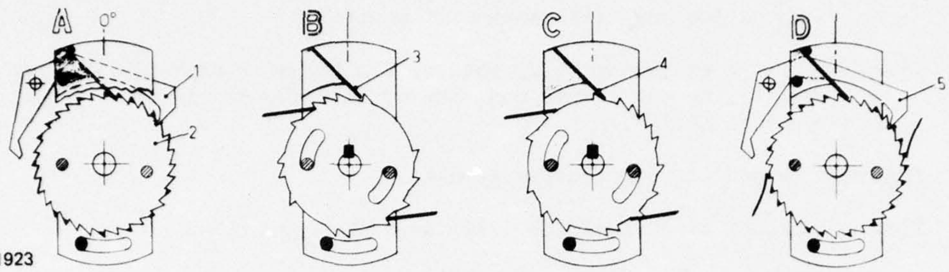

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Figure 3 INITIAL POSITION SD CODE MECHANISM

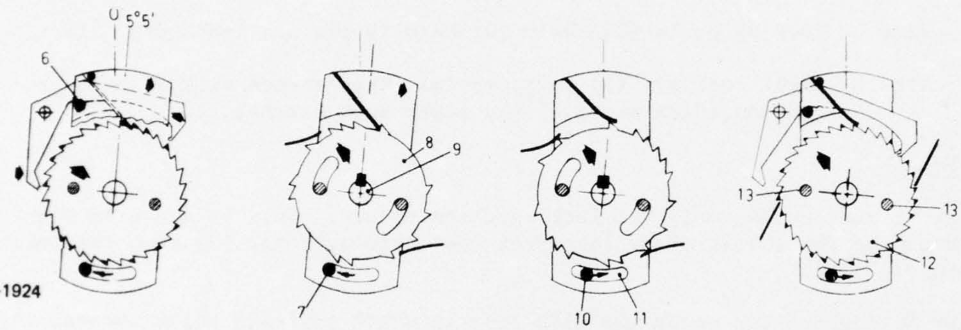

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Figure 4 MID-STROKE POSITION SD CODE MECHANISM

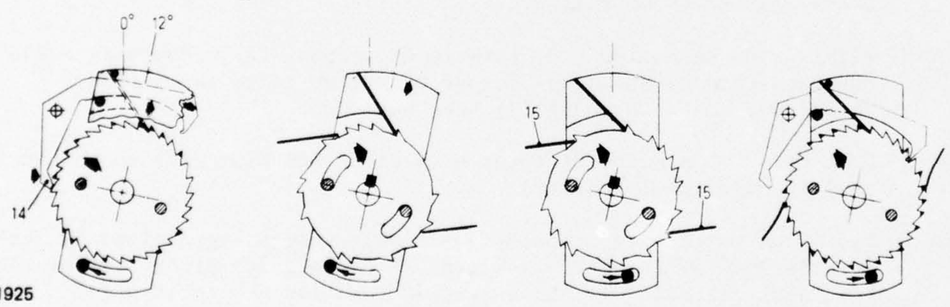

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Figure 5 FINAL POSITION SD CODE MECHANISM

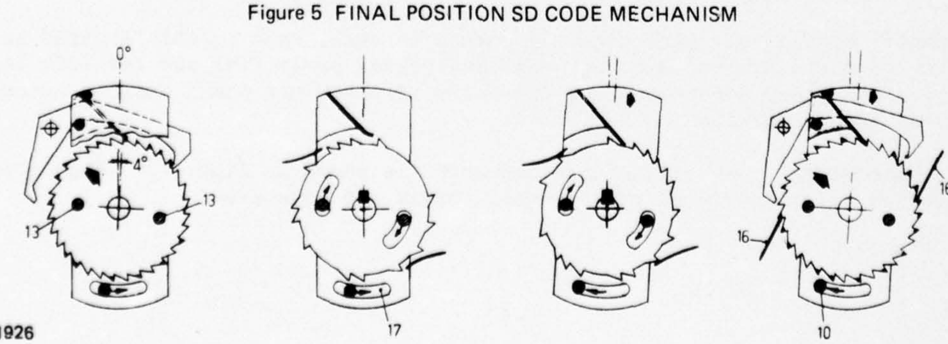

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Figure 6 ABORT POSITION SD CODE MECHANISM

View B Drive mechanism (7) rotates drive pawl (3) which rotates drive ratchet (8) through the ratchet tooth. Main shaft (9) rotates via key.

View C Right drive mechanism (10) rotates in clearance slot (11) so that drive pawl (4) remains in position.

View D Right lock ratchet (12) rotates via transfer pins (13). Lock arm (5) is not cammed out, but no interference is present to prevent motion.

c. Figure 5 -- End of normal drive stroke.

View A Ratchet overtravel stop (14) cams into position.

View B Drive ratchet (8) at end of 1 drive stroke. Main shaft (9) has rotated 1 code increment.

View C Locking pawls (15) hold ratchets in the new indexed position.

View D Right lock arm (5) in potential interference with a coded protrusion (dark area) of the right lock ratchet (12).

Abort Mode

In an abort mode cycle, only the lock ratchets rotate. This is shown in Figure 6 which would be the result of an incorrect code sequence starting from the initial position of Figure 3.

View D Right drive mechanism (10) rotates drive pawl (4) which rotates lock ratchet (12). Abort locking pawls (16) hold ratchets in the partially advanced position.

View C Right drive mechanism (10) rotates drive pawl (4). However, drive ratchet (8) does not move because the drive tooth is missing. Therefore, the main shaft (9) does not move.

View B Left drive mechanism (7) rotates in clearance slot (17) so that drive pawl (3) remains in position.

View A Left lock ratchet (2) rotates a partial cycle being limited by the interference of the left lock arm (1) and a coded protrusion of the left lock ratchet (2). Lock ratchet rotation due to transfer pins (13).

The geometry of the code mechanism components is such, that in this aborted position, the ratchets are captured between the locking pawls (16) and the left lock arm (1). No further advancement of the drive ratchets can occur until a manual unlock and reset operation is performed.

A three dimensional view of the code mechanism is shown in Figure 7. This shows the relative relationship of the ratchets, pawls and lock arms.

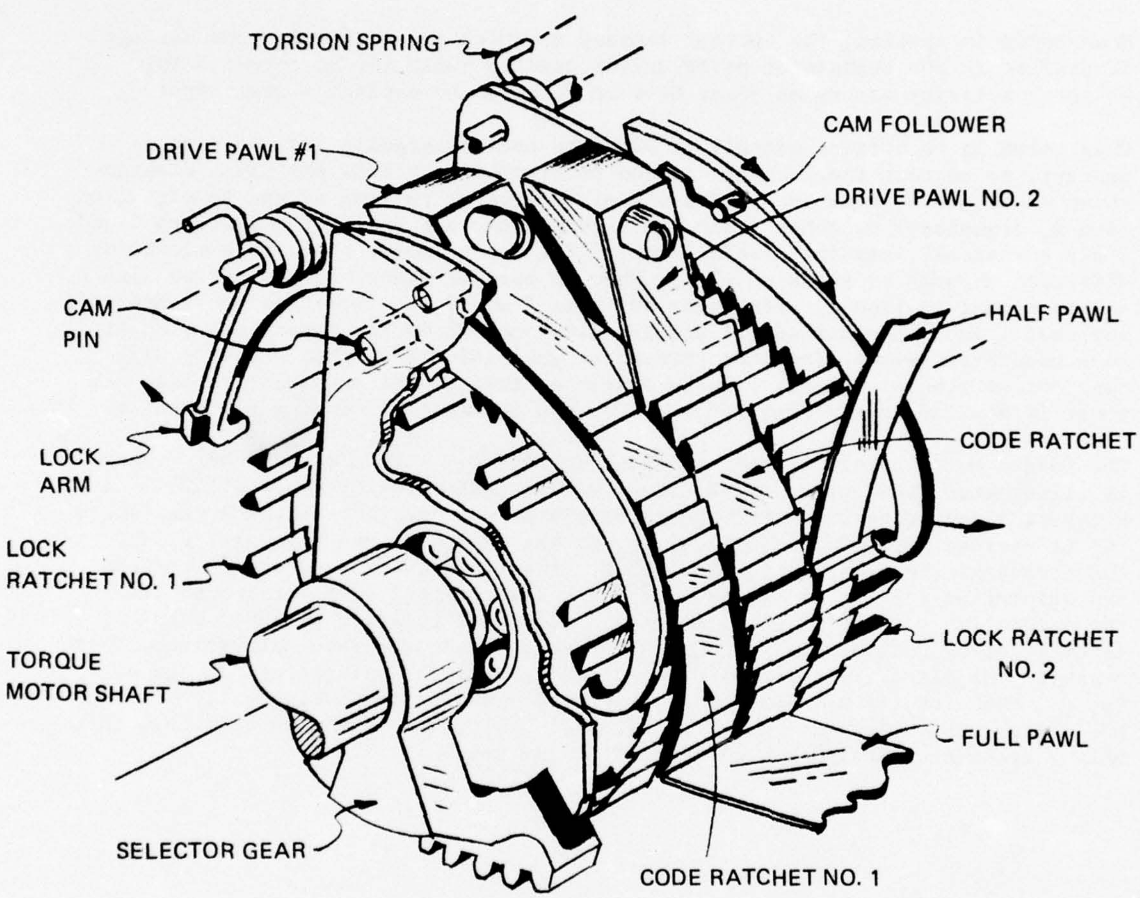


Figure 7 THREE DIMENSIONAL VIEW OF THE CODE MECHANISM

3.3 ELECTRONICS AND OPTICS

The Switch Driver Electronics consists of an optical fiber/photo-detector interface, sensing electronics, and circuitry to interface the optically coded input to a bidirectional, limited angle torque motor which provides the switch driver actuation.

The SD Electronics Subsystem accepts data as an optical pulse train on two fiber optic signal cables. The optical data is digital in nature and the two signal lines are complementary.

When power is applied, the optical sensing circuits are energized, and voltage is present at the transistor power driver used to pulse the dc torque motor. No motor activity occurs at power or when there is no optical signal input.

When there is no optical signal, or when the optical signals are not complementary, no current flows in the torque motor winding. From the block diagram shown in Figure 8, when an optical signal is present on line A, and no signal on line B, transistor switches 1 and 4 are turned on, and transistor switches 2 and 3 are turned off, causing displacement of the torque motor shaft in a clockwise direction through an angle of $+15^{o}$. When an optical signal is present on line B, and no signal on line A, transistor switches 2 and 3 are turned on and transistor switches 1 and 4 are turned off causing displacement of the torque motor shaft in a counterclockwise direction through an angle of -15^{o}. This activity will continue as long as optical signals appear at the optical sensing circuits, and power is applied to the transistor driver and the optical sensing electronics.

The Torque Motor Driver Circuit is shown in Figure 9. When either phototransistor is illuminated, the output pulse drives either transistor Q_1 or Q_6 (2N2222A) into saturation depending upon which phototransistor was excited. For the case where PT_1 is excited, transistors Q_4, Q_5, Q_6, Q_7 and Q_8 are driven into saturation. This connects the plus (+) terminal of M_1 (the DC torque motor) at +28V minus the saturation voltage of Q_8, and the minus (-) terminal of M_1 at ground plus the saturation voltage of Q_4, producing a clockwise rotation of 15^{o}. When PT_2 is excited, transistors Q_1, Q_2, Q_3, Q_9 and Q_{10} are driven into saturation. This connects the minus (-) terminal of M_1 at +28V minus the saturation voltage of Q_9, and the plus (+) terminal of M_1 at ground plus the saturation voltage of Q_3, producing counterclockwise rotation of 15^{o}. Q_{11} and Q_{12} are used to ensure that only 2 transistor switches will be "on" at any time.

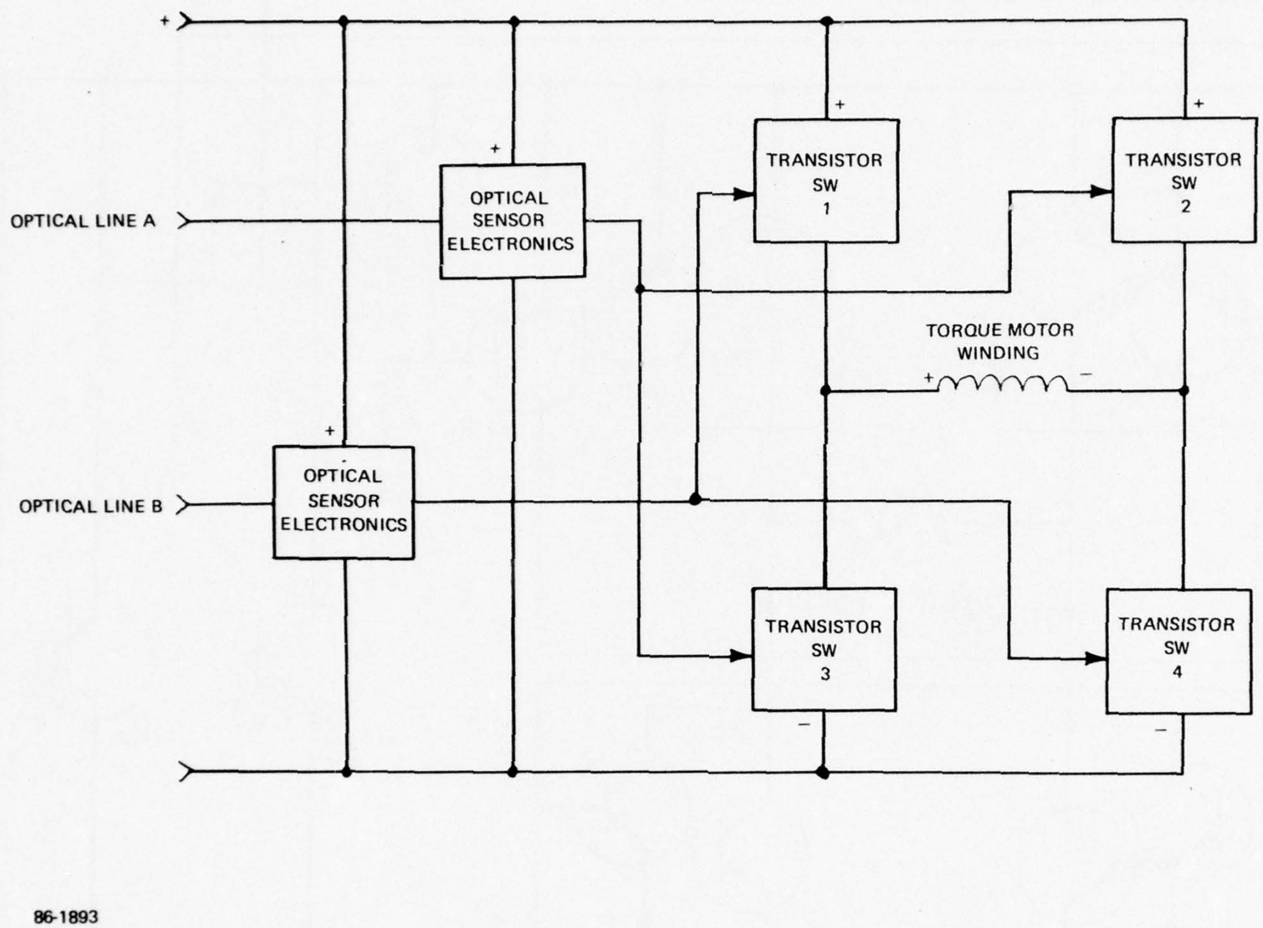


Figure 8 BLOCK DIAGRAM -- OPTICAL/ELECTRONICS SUBSYSTEM

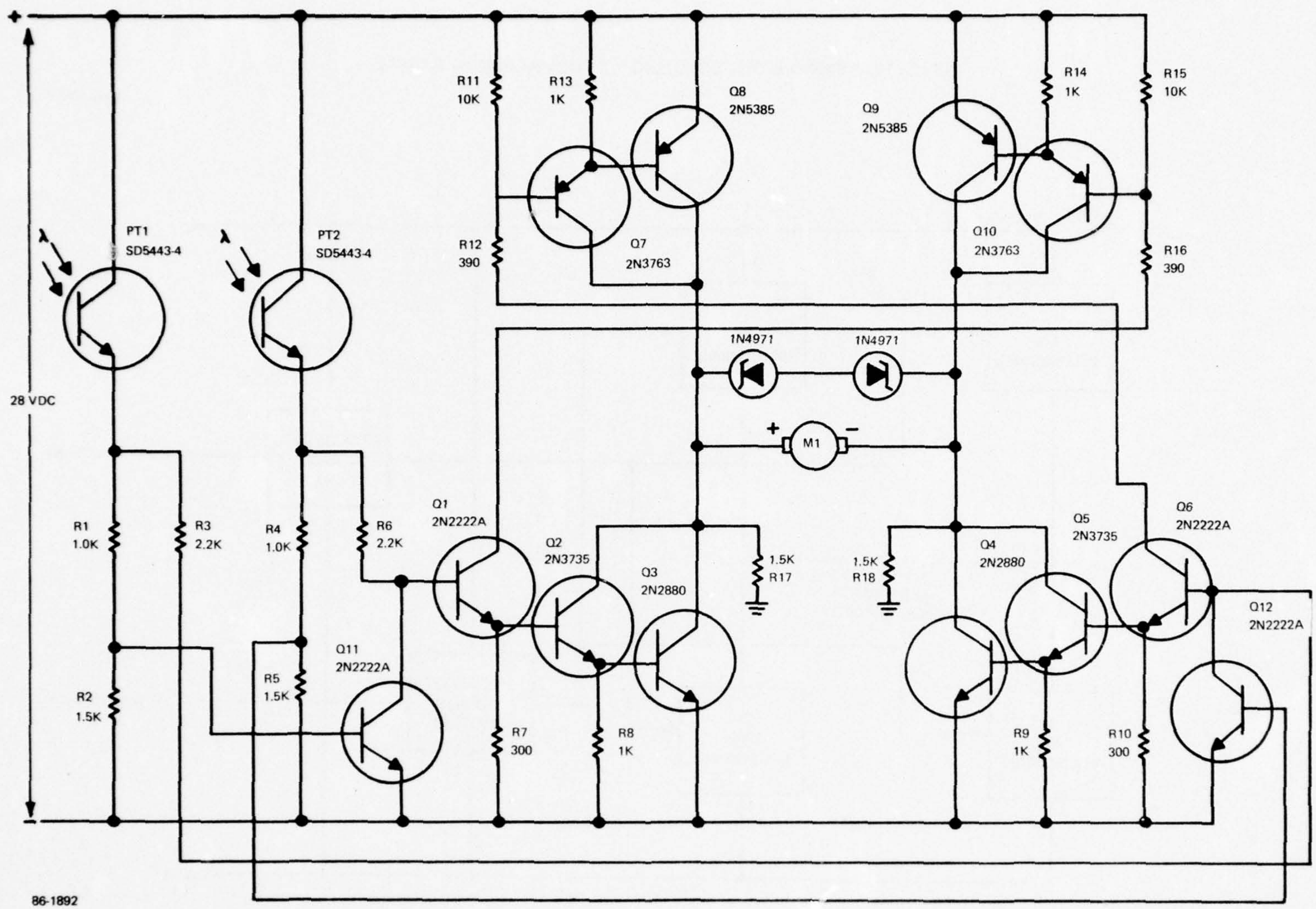


Figure 9 SCHEMATIC -- SD ELECTRONICS

4.0 MECHANICAL DESCRIPTION

Figure 10 is a layout of the SD. The area indicated as the optical/electronics module (1) can ultimately house the miniaturized optics and hybridized electronics.

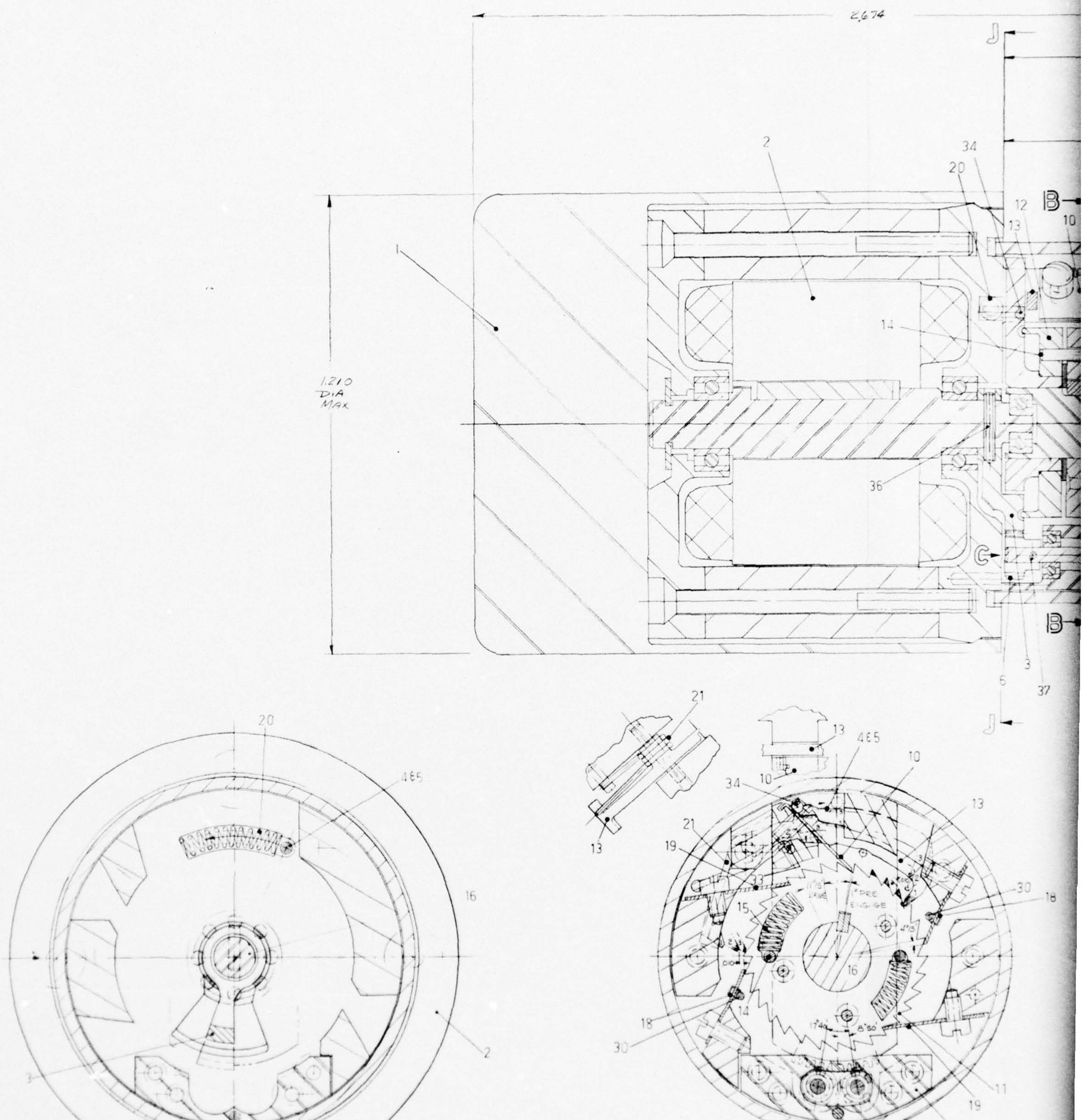
Referring to Figure 10, an input optical code is converted to an electrical pulse by the electronics module (1). This drives the torquer (2) in a direction dictated by the code. An optical signal on line 1 would result in a positive electrical pulse which drives the torquer clockwise. A drive gear (3), keyed to the torquer rotor, is coupled to drive pawl 1 (4). The drive gear is also coupled to drive pawl 2 (5) through gears (6), (7), (8) and drive ring (9). The interrelationship of these parts is shown in Views C and D of Figure 10. A clockwise rotation of the torquer moves drive pawl 1 by bearing against surface "y" (View C). At the same time the drive ring goes counterclockwise via the gear train and moves away from surface "z" of drive pawl 2 (View D). Thus drive pawl 2 remains stationary. Conversely a counterclockwise rotation of the torquer will rotate drive pawl 2 clockwise by bearing against surface "z" while drive pawl 1 remains stationary. By using this technique, a single drive mechanism (torquer) will drive either pawl clockwise solely dependent upon the polarity of the electrical signal input.

A pawl (10) mounted on the drive pawl mechanism rotates the ratchet assemblies. The ratchets are designed to respond to a correct code by advancing, or, to an incorrect code, by aborting the mechanism. This is accomplished by having the drive ratchet (11) configured so that a tooth is presented only to one of the pawls at a time. If that pawl is actuated, the ratchets advance. If the incorrect pawl is actuated, the drive ratchet will not move (no tooth on the drive ratchet) and the unit will be locked up by the lock ratchets (12) and lock arms (13) as shown in Figure 6, View A.

If the code is correct, the central drive ratchet will be advanced by the pawl, and the correct lock arm will be cammed into the proper position by a pin (33) in the drive pawl. Transfer pins (14) allow the drive ratchet to carry both adjacent lock ratchets along with it. A spring (15) maintains the relative position of the ratchets. As long as all three ratchets advance in this manner, the drive ratchet will rotate the main shaft (16) via key (17), driving through the code.

If the code is incorrect and does not agree with the ratchet configuration, only the lock ratchets will advance and the correct lock arm will not move. The mechanism will thus lock up, with the protrusion of the lock ratchets being caught by the hook on the lock arm. The lock ratchets will be held in this interference position by a pair of locking pawls (18).

Each step of the ratchet assembly is controlled from overshooting by the lock arm shown in Figure 5, View A. Locking pawls (19) maintain the ratchets in the new indexed position. The drive pawl mechanism and torquer are driven back to the neutral position by the return springs (20) and the lock arms are returned to the initial position by torsion springs (21) and limit pin (34).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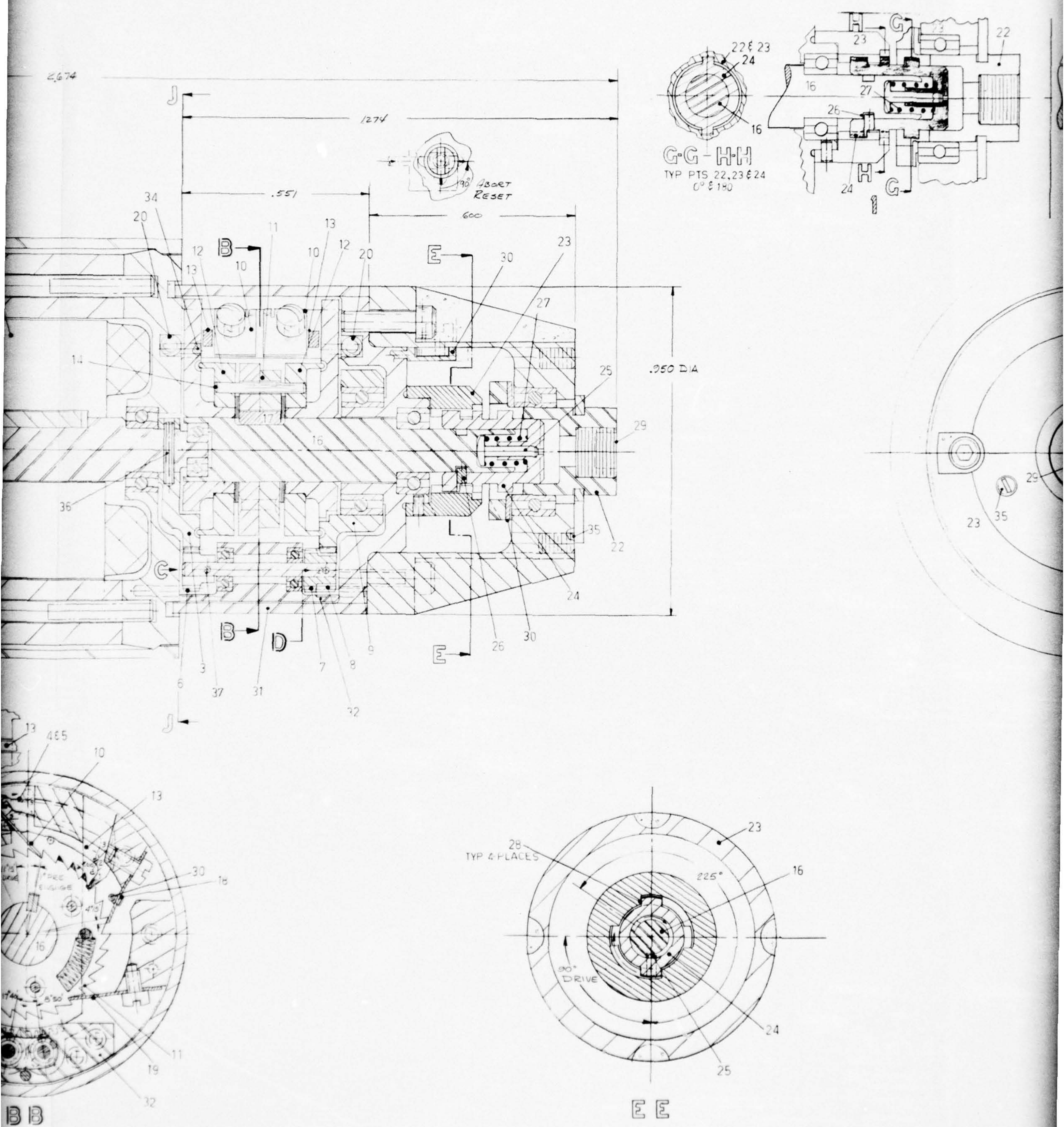
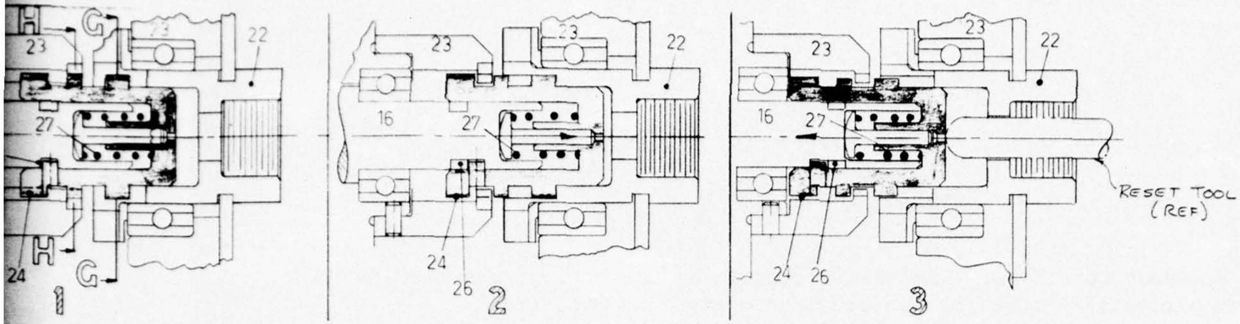
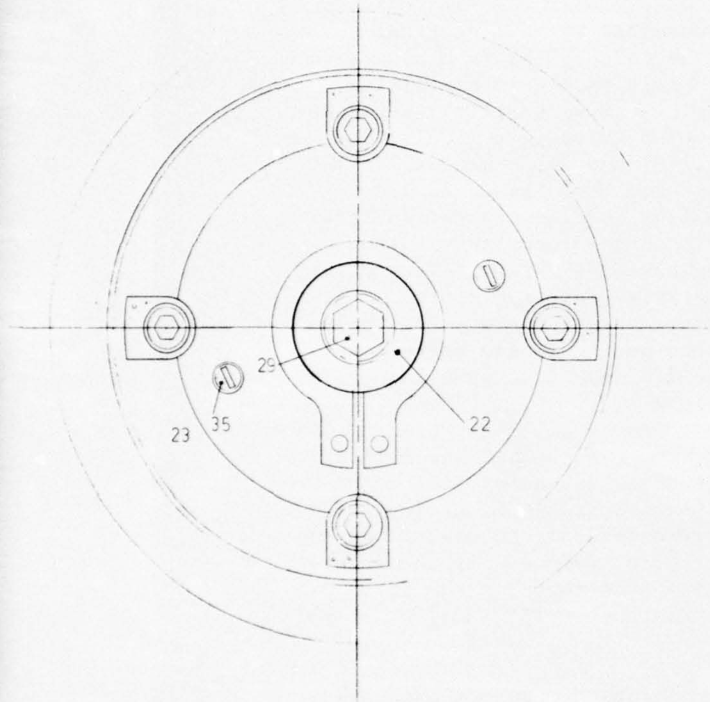
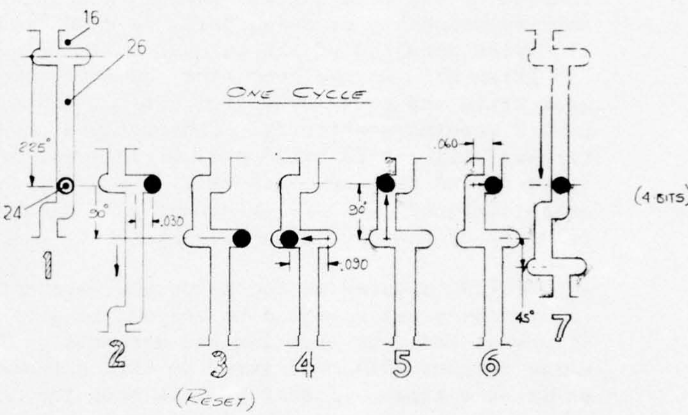


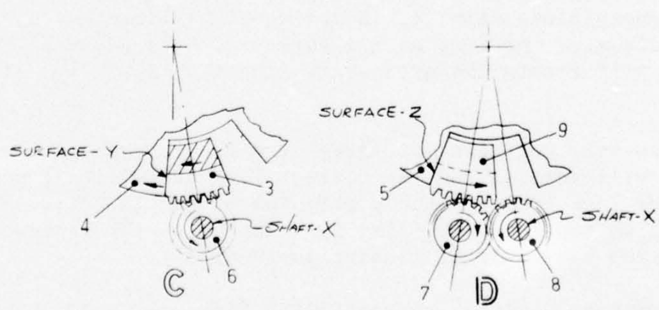
Figure 10 LAYOUT OF SD







1. OPTICAL/ELECTRONICS MODULE
2. TORQUER
3. DRIVE GEAR
4. DRIVE PAWL #1
5. DRIVE PAWL #2
6. PINION
7. PINION
8. PINION
9. DRIVE RING
10. DRIVE PAWLS
11. DRIVE RATCHET
12. LOCK RATCHETS
13. LOCK ARMS
14. TRANSFER PINS
15. SPRING
16. MAIN SHAFT
17. KEY
18. LOCKING PAWLS
19. LOCKING PAWLS
20. RETURN SPRING
21. TORSION SPRING
22. OUTPUT SHAFT
23. STRUCTURE
24. CLUTCH
25. GUIDE PIN
26. CAM TRACK
27. CLUTCH SPRING
28. STOP
29. RESET PLUG
30. THRUST WASHER
31. WINDOW
32. BEARING BLOCK
33. CAMMING PIN
34. LIMIT PIN
35. RESET/ACCESS SCREW
36. DRIVE GEAR PIN
37. PINION PIN



The main shaft of the SD is always locked in position. Any forward motion would be similar to an abort mode; i.e., the main shaft would rotate the ratchets via the key but neither locking pawl would be removed. A reverse rotation is prevented by the locking pawls (19).

After receiving 20 correct codes, the main shaft incrementally indexes 225^{o} (32 ratchet teeth -- 20/32 of a revolution). However, the output shaft (22) has remained stationary, being locked to structure (23) until completion of the 20th bit by the clutch (24). The mechanics of operation of the clutch is shown in functioned schematic Views 1 and 2 of Figure 10. A guide pin (25), pressed into the clutch rides in a cam track (26) which is cut into the main shaft. Plan views of the cam track/guide pin relationships are shown in schematic cycle diagrams 1 through 7 of Figure 10.

Initially (View 1), the output shaft is restrained from moving, being locked to the clutch which is locked to the structure. These locks are shown in Sections G-G and H-H respectively. The clutch is under a spring load by the clutch spring (27) but is prevented from moving by the configuration of the cam track and guide pin.

After receiving 20 code bits, the main shaft and therefore cam track advance to position 2. The clutch now snaps to a new position under the force of the clutch spring. This motion uncouples the clutch from structure (View 2) and couples the clutch to the main shaft through the guide pin. Eight more electrical pulses will now rotate both the main and output shafts 90^{o} (8-32nds of a revolution - plan View 3). Further rotation of the output shaft and mechanism is prevented by positive structural stops (28). A reverse rotation is prevented by the locking pawls (19). The unit is thus locked in the desired position.

4.1 RESET OF SWITCH DRIVER

The SD uses a 32 tooth ratchet. The apportionment of these 32 increments is as follows:

20 increments	Verify code word
8 increments	Rotate output shaft 90° (8/32 revolutions)
4 increments	Reset

The SD can be readily reset from either an abort, partial or full cycle mode.

Normal Position

End of 28 correct code bits (90° rotation of output shaft). The following procedure will reset the unit from the final output position:

a. Remove reset plug (29).

b. Insert rounded dowel (1/16 in.) into the reset cavity to drive clutch to the position shown in View 3 of Figure 10. This corresponds to cam track position 4.

c. Rotate the output shaft back to the original position. Clutch through guide pin follows cam track position shown in View 5.

d. Release dowel. Clutch will snap to the position shown in View 6.

e. Apply 4 code pulses to the torquer. The mechanisms are now back to the initial positions (Views 7 and 1).

Partially Advanced Position

The unit can be reset from any partially advanced position by applying the proper code to complete the actuation cycle and then proceeding for a normal reset as described above. The proper code is embossed on the right lock ratchet and can be seen through the view window (31).

Abort Position

When the unit is in the abort mode position, reset is accomplished as follows:

a. Remove reset access screws (35). Insert resetting tool. This will cam the locking pawls (18) out of engagement with the lock ratchets. The lock ratchets will then return to their initial relationship with the drive ratchet being driven by the spring (15) and transfer pin (14).

b. The unit is now out of the abort mode but is in a partially advanced position.

c. Replace the reset access screws.

d. Apply the proper code to complete the actuation and normal reset cycles.

4.2 OPTICAL FIBER/PHOTODETECTOR MECHANICAL INTERFACE

The optical input fiber optics cable is specified as a fiber optic bundle, 0.045-inch in diameter. The spectral range is 800 to 900nm with an optical bandwidth of 50 nanometers, and a Radiant Power Input (RPI) of 10^{-5} watts in the "on" state, and 10^{-8} watts in the "off" state.

Figure 11 shows a single optical channel termination in cross section. The bundle has the jacket stripped and a brass ferrule epoxied in place at the end. The fiber-optic cable/ferrule surface is polished to achieve optical flatness on the fiber end. ATO-46 lensed can, welded to a Kovar eyelet, is epoxied to the ferrule in the axial position which places the fiber ends in the focal plane of the lens. The terminated fiber/optic cable is then inserted into a Delrin adapter and slipped over the detector which is housed in a TO-46 lensed can, epoxied together, and the detector is then soldered directly to the printed circuit board. In this manner, minimum area is used to effect the fiber/optic cable/photodetector interface. Mechanical tolerances assure optimum repeatability in coupling the optical signal to the photo detector.

Photodetector Selection

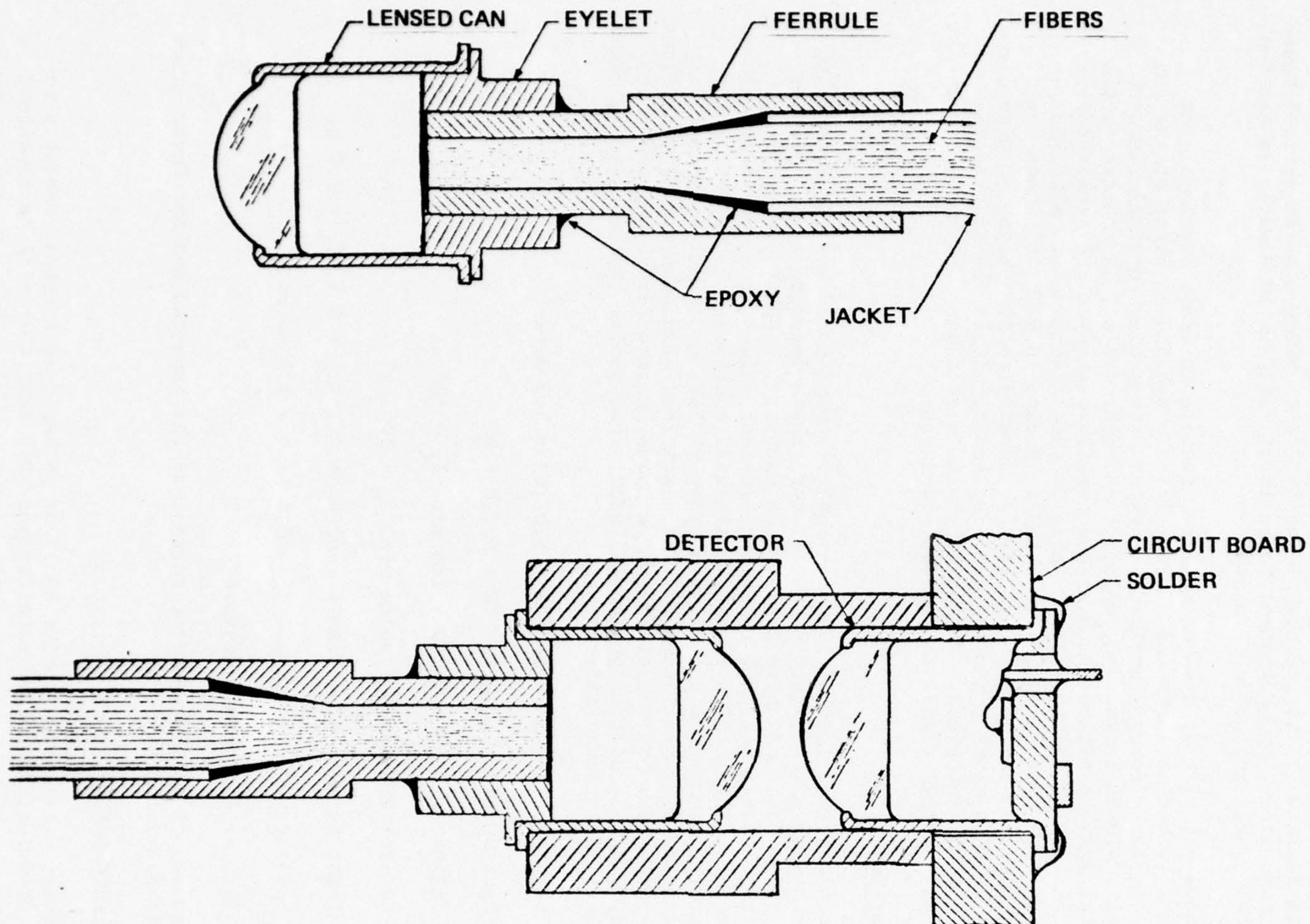
The ultimate electrical load of the electronics subsystem is a limited angle dc torque motor having a rare earth magnet stator, which develops 17.5 oz-in peak torque at a power input of approximately 100 watts. The power source is a constant voltage source designed to deliver current pulses at a nominal 28 vdc to the torque motor. The total operating cycle will consist of 28 pulses in a 1 second interval. Assuming a pulsed duty cycle of 50%, at 30 pulses/second, the pulse duration is 16.67 milliseconds. The electrical time constant of the torque motor is approximately 500 microseconds. Considering the foregoing, the photodetector proposed is a silicon phototransistor, Spectronics type SD 5443-4, whose principal electrical characteristics are:

I_L	Light Current 16.0 ma VCE = 5.0V,H* = 5.0 mw/cm^2
I_D	Dark Current 100 ma VCE = 30V,H = 0
B_{VCEO}	Collector Breakdown 30 volts min. $I_C = 100\ \mu a$
B_{VECO}	Emitter Breakdown 7 volts min. $I_E = 100\ \mu a$
t_r	Light Current Rise Time 8 μsec R_L = 1K, V_{CC} = 5 V, I_L = 1.0 ma
V_{CESat}	Saturation Voltage 0.2V I_C = 0.4 ma H = 5.0 mw/cm^2
0**	Angular Response 9 degrees

The determination of phototransistor current at the expected Radiant Power Input is derived in Section 7.4.

4.3 DRIVER PACKAGING

The torque motor driver electronics could be packaged as a hybrid assembly together with miniaturized optics terminations such that they will be contained in



86-1932

Figure 11 FIBER OPTIC CABLE TERMINATION AND DETECTOR INTERFACE

a 1.125-inch diameter x 0.5-inch volume. The total power dissipation is expected to be less than 15 watts during operation. Special attention will be given to adequate heat sinking of the dissipating elements, which are primarily the power transistor switches.

5.0 CONFORMANCE TO DESIGN REQUIREMENTS

The Switch Driver has been designed to satisfy all the requirements delineated in the contractural documents and those agreed to by Picatinny Arsenal and Avco/SD personnel. The following is a list of these requirements along with a description showing design conformance.

5.1 FUNCTIONAL REQUIREMENTS

5.1.1 Optical Code/Electrical Power

The SD is to respond only through two actuating input stimuli-optical code and electrical power combined.

The driving mechanism is a limited angle dc torque motor which converts electrical power to a mechanical rotational output. The direction of rotation (CW or CCW) will be a direct function of the polarity of the electrical signal. The electrical power can only be applied to the torque motor when an optical signal is present. The optical stimulus is converted to an electrical signal which supplies current drive to a transistor power driver. The power driver produces bi-directional rotation of the torque motor dependent upon the input optical code. No rotation of the torque motor will occur if either the electrical power and/or optical stimuli is not present.

5.1.2 Output

- The output shaft must rotate 90° only after receipt of the correct code.

  The output shaft is initially locked to the structure of the SD. This lock is maintained through and including 19 correct code bits. At the completion of the 20th correct code bit, the lock is removed and the driving torque is then (and only then) connected to the output shaft. If at any time during and including the first 20 bits an incorrect complementary code is received, the lock ratchets will partially advance and will become locked by the locking pawls and lock arm. The unit will then be aborted.

- Provide a 10 in-oz. minimum torque.

  The torque motor has a peak torque (Tp) of 17.5 in-oz. The output torque (T) varies by twice the cosine of the mechanical indexing angle (θ), i.e., $T = T_p \cos 2\theta$. If the mechanical angle is 15° (11.25° per tooth + 3.75° for backlash, overthrow, etc.) the torque is 15.16 in-oz. If 4.82 in-oz. is required to index the mechanism in the proper time cycle then the output shaft will have a 10.34 to 12.68 in-oz. output torque. (See Section 6.1 for analysis.)

- Output shaft must lock in the on, off, and abort positions.

  The output shaft is always in a locked mode and can only be advanced by driving the mechanism through the code. It is either locked to structure (0-19 bits) or coupled to the main shaft (20-28 bits). The main shaft is

also locked in position. It is prevented from unintentionally advancing by the lock arms on returning by the locking pawls (19). In the abort mode the main shaft is locked in position by the lock arm and locking pawls (18).

5.1.3 Reset by External Means

The SD can be reset from the locked and/or abort modes without disassembly. A detailed description of the reset is presented in Section 4.1. Basically, reset is accomplished as follows:

- From the armed position

  a. Uncouple the clutch (requires manual movement of clutch).

  b. Rotate output shaft back to safe position (release clutch).

  c. Apply a 4 bit word to the torque motor (word could be coded) to complete rotation of main shaft.

- From the abort position

  a. Uncouple locking pawls (through access ports).

  b. Complete actuation cycle to arm unit.

  c. Proceed as above.

5.1.4 Fail Safe

The SD should fail safe by ceasing to respond to further signal inputs any time an improper complementary code signal is detected.

At any time during the first 20 bits an improper code signal is received, the lock ratchets will partially advance where they will become locked by the locking pawls (18) and lock arm (13). The unit will be aborted. If the code bits are received on both lines or none are received at all, no electrical signal is delivered to the torquer and no main or output shaft movement occurs.

5.1.5 Response Time (1 second maximum)

The analyses presented in Section 7.1 show that the SD will function in approximately 0.5 second with a 10 in-oz. resisting load on the output shaft.

5.2 PROBABILITY

5.2.1 Premature Random Probability

The probability of premature operation of the SD output due to applied signals randomly generated, in the proper, or any other format, shall be less than 1 in 10^6 in all environments.

The output shaft of the SD will be locked to the structure of the mechanism until 20 correct bits of code signals have been received by the optical/electronics package. These signals can be construed as being either a "0" or a "1" with each having the same probability of occurrence. Therefore, the probability of the output shaft becoming unlocked from the structure by a random signal is 1 in 2^{20} or 1 in 1.05×10^6 or 9.54×10^{-7}.

In addition, the output shaft is still locked at this point by the mechanism which requires 8 more signals to rotate. These signals could also be a coded word in which case the probability of getting a 90^o output from a random signal is 1 in 2.68×10^8 or 3.73×10^{-9} (i.e., 1 in $2^{(20+8)}$ = 1 in 2^{28}).

5.2.2 Premature Due to Component Part Failure

The probability of an inadvertent or premature operation of the SD output due to component part failures (electrical or physical) shall be less than 1 in 10^5 in normal environments.

The SD is designed so that no single component failure will cause the output shaft to rotate; rather it takes a series of positive events.

Because the unit has been designed to drive through the code, the code mechanism must fail, or be by-passed, and torque, either from the torquer or from an external source, must be applied. For the code mechanism to fail either the 20 protrusions of the lock ratchets or the two lock arms must fail. The design of these members are with sufficient safety factor so that each will have a probability of failure less than 1 in 1000 in normal environments. This makes the probability of code mechanism failure less than 1 in 10^6 since at least two members must fail.

In addition, no stored arming energy is used in the SD. This means that the torquer must also fail or driving torque must be externally applied. This has the effect of further reducing the probability of output due to component failures.

5.2.3 Premature Due to Abnormal Environments

The probability of inadvertent or premature operation of the SD output should be less than 1 in 10^3 when exposed to levels of abnormal environments that an associated strong link is required to survive.

A "strong link/weak link" philosophy has been used in the design of the SD. The output shaft and associated ratchets, locking pawls, lock arms, structure, etc., are of rugged construction (strong link). The drive pawls, which index the mechanism by driving through the code, are designed to be the weak link, their

stress level being proportionally lower than the strong link components so that they would fail first in any abnormal condition.

The established failure priority (see Section 7.2) removes the drive torque from the code mechanism -- first by a buckling failure of the drive pawl and second by sheering the pin coupling the torquer to the drive gear.

5.3 PHYSICAL CONSTRAINTS

5.3.1 Weight (4 oz. maximum)

The estimated weight of the breadboard design (Figure 10) with a hybrid electronics circuit is 4.48 oz. The weight breakdown is as follows:

Optical/Electronics Package	0.44 oz.
Torquer	1.60 oz.
Structure	1.42 oz.
Mechanism	1.02 oz.
	4.48 oz.

However, discussions with torque motor vendors indicate that the torque motor weight and size can be significantly reduced for our application (limited angle). This would require a small development effort which should be entertained during the next program phase. The projected weight would be 3.88 oz. which is based upon a 1.0 oz. projected torque motor weight.

5.3.2 Size

The size of the SD shall be limited by the equivalent volume of a 0.93 x 0.93 x 2.125 rectangular parallelepiped (1.84 cubic inches). The size of the breadboard SD (Figure 10) with hybridized electronics and miniaturized optics is 2.26 cubic inches. However, the torque motor development effort will reduce the design configuration to approximately 1.9 to 2.0 cubic inches without advancing the current state-of-the-art.

5.3.3 Storage Life (20 years)

To obtain a long term 20 year storage life cycle, the following design precautions are being taken:

- Use of compatible metals.
- Use of fungus non-nutrient materials.
- Non use of outgasing materials.
- Non use of age hardening materials.
- Non use of materials subject to cold flow.
- Environmentally sealed.

6.0 DESIGN FEATURES

- The decoding concept uses only physical code storage methods. The drive ratchet and the lock ratchets have the code machined into their configuration.
- Electronic logic decoding techniques that result in the simple switching of power to the rotary driving source and/or to an output shaft unlocking feature are not used. The optical/electronics package merely converts the code to an electrical signal which is transmitted to the torquer. For the mechanism to advance the optical code must be correct.
- The physical decoding feature (drive ratchet) is located between the source providing the power for rotation of output shaft (torquer) and the output shaft itself. For the output shaft to advance the mechanism must drive through the code.
- The entire unique signal (code word) must be verified prior to initiation of output shaft rotation. No rotation of the output shaft occurs until the 21st signal. During the code word initiation the output shaft is locked to the structure of the mechanism. If an incorrect code bit is delivered the unit will lock up and fail safe.
- A physical barrier not prone to single point failures, which prevents output shaft rotation by the driving force, is present until the entire code word is verified. The output shaft is locked to structure until the complete code word is sent.
- The decoding process detects the presence of improper code events by locking out the device. The device does not respond to 2 "1"s or 2 "0"s nor is there any maximum time limitation on the delivery of the code (i.e.: 10 correct bits now 10 correct bits later will unlock the output shaft).
- The proper performance of a deliberate sequence of physical events is necessary to accomplish the decoding process. The improper code response feature is inherent in the design and not dependent on reactions which could be prevented by single, or combinations of, short or open circuit failures. The response to an improper code is the impending lock on the lock ratchets.
- Dual locks on the output shaft.
- Use of standard hardware items (ratchets, torque motors, etc.).
- Flexibility to increase code premature probability from 1 in 10^6 to 1 in 10^9 without a significant design change.
- All components to the greatest extent possible are balanced to provide good dynamic stability.
- Reset is simple and is accomplished without the use of special tools.
- Single torque motor used to index code mechanism and provide torque to output shaft.
- Code not constrained can by any combination of "0"'s or "1"'s.

- Reverse drive mechanism cannot index both drive arms simultaneously because of controlled clearances between the drive gears and drive pawls; i.e., the code cannot be bypassed if the drive pawl mechanism "freezes" to the main shaft.
- The code mechanism uses the principle of active advance and passive abort. Therefore, any jamming tends to abort the system.
- No stored arming energy is used.

7.0 SUPPORTING DESIGN ANALYSES

7.1 MECHANISM FUNCTION TIME

The response of the system can be determined by analyzing one complete cycle of the code word. The forward stroke of a cycle can be broken down as follows:

$0 - 1^\circ$	Take up of backlash in reversing mechanism gear train.
$1 - 2^\circ$	Take up of backlash between drive pawl and drive ratchet.
$2 - 13^\circ\ 45'$	One ratchet tooth index.
$13^\circ\ 45' - 15^\circ$	Overtravel.

Therefore, one complete cycle requires a 15 degree forward stroke of the torquer and a 15 degree return stroke.

System Parameters

The parameters of the system are presented in the following paragraphs.

Driving Torque

The torque motor has a peak torque (T_p) of 17.5 in-oz. The output torque (T) varies by twice the cosine of the mechanical indexing angle (θ), i.e., $T = T_p \times \cos 2\theta$. If the mechanical angle is 15°, the driving torque will vary from 17.5 in-oz at 0° to 15.2 in-oz at 15° (i.e., $T = 17.5 \times \cos 30 = 15.16$).

System Inertia

The effective inertia (i.e., moment of inertia caused by rotation about the torque motor axis) of each of the components of the system are shown in Table I along with a matrix showing where applicable. For conservatism the total inertia is used during the complete stroke even though there are portions of the drive stroke in which all parts do not move, (i.e., first degree only torque motor, middle portion of stroke lock arms do not move, etc.).

Resisting Torque

The resisting torque of the components of the system are shown in Table II along with a matrix showing where applicable. For conservatism the maximum frictional resisting torque of the drive and locking pawls are used even though they do not occur simultaneously during the drive stroke.

Analysis

$$T = I\ddot{\theta}$$

TABLE I

EFFECTIVE SD INERTIAS

	Moment of Inertia (in-lb-sec^2)	Drive Stroke First 20 Cycles	Drive Stroke Last 8 Cycles	Return Stroke
Torque Motor	7.175×10^{-6}	X	X	X
Reversing Mechanism	1.679×10^{-6}	X	X	X
Drive Pawl	1.202×10^{-6}	X	X	X
Lock Arm	0.625×10^{-6}	X	X	X
Drive and Lock Ratchets	1.125×10^{-6}	X	X	-
Torque Motor Shaft	0.067×10^{-6}	X	X	X
Main Shaft	0.085×10^{-6}	X	X	-
Clutch	0.012×10^{-6}	-	X	-
Output Shaft	0.074×10^{-6}	-	X	-
Totals		1.196×10^{-5}	1.204×10^{-5}	1.075×10^{-5}

TABLE II

RESISTING TORQUE SD

	Resisting Torque (in-oz)	Drive Stroke First 20 Cycles	Drive Stroke Last 8 Cycles	Return Stroke
Return Spring (Ave)	2.70	X	X	-
Locking Pawls (Max.)	0.88	X	X	-
Abort Lock Pawls (Max.)	0.61	X	X	-
SD Friction (Est.)	0.50	X	X	X
Drive Pawl (Max.)	0.13	X	X	X
Output Shaft Torque Load	10.00	-	X	-
Total		4.82	14.82	0.63

For a Constant Torque (T)

$$\ddot{\theta} = \frac{T_{net}}{I}$$

$$\theta = 1/2 \frac{T_{net}}{I} t^2$$

$$t = \left[\frac{2\theta I}{T_{net}}\right]^{1/2}$$

- <u>Forward Stroke First 20 Cycles</u>

$$\theta = 15^{o} = 0.2618 \text{ rad}$$

$$I = 1.196 \times 10^{-5} \text{ in-lb sec}^2$$

$$T_{net} = \left[\frac{17.5 + 15.16}{2} - 4.82\right] \div 16 = 0.7194 \text{ in-lb}$$

$$t = \left[\frac{2 \times 0.2618 \times 1.196 \times 10^{-5}}{0.7194}\right]^{1/2} = 0.002950 \text{ sec}$$

$$t = 2.950 \text{ milliseconds}$$

- <u>Forward Stroke Last 8 Cycles</u>

$$I = 1.204 \times 10^{-5} \text{ in-lb sec}^2$$

$$T_{net} = \left[\frac{17.5 + 15.12}{2} - 14.82\right] \div 16 = 0.0944 \text{ in-lb}$$

$$t = 8.172 \text{ milliseconds}$$

- <u>Return Stroke</u>

$$I = 1.075 \times 10^{-5} \text{ in-lb sec}^2$$

$$T_{net} = (2.70 - 0.63) \div 16 = 0.1294 \text{ in-lb}$$

$$t = 6.596 \text{ milliseconds}$$

- Time Delay

  The torque motor has an electrical time constant of 0.35 millisecond. If we allow 0.8 millisecond time delay in which time we consider no motion has occurred, this parameter will be treated conservatively.

- Conclusion

  A conservative estimate of the total cycle time capability of the Switch Driver is 348 milliseconds. This estimate is based on a duty cycle of 4 milliseconds on, 7 ms off for the first 20 code cycles (to unlock the output shaft) and 8 code cycles of 9 ms on 7 ms off to rotate the output shaft 90°. If a 50% duty cycle for all 28 bits is desired, the cycle time is 504 ms (i.e., 28 (9 + 9) = 504). The total time can be reduced further by matching the forward and return cycle times.

7.2 STRESS ANALYSIS OF CRITICAL ITEMS ASSOCIATED WITH "WEAK LINK/STRONG LINK" PHILOSOPHY

A stress analysis of the drive and abort mechanisms was conducted for a worst case abort mode. The results of this study are shown in Table III along with the material chosen and resulting safety factors.

The rationale used in the selection of material is the desired priority of failures in an abnormal condition. These are presented in the chronological order of failure:

- Drive Pawl (10) -- S.F. buckling 2.6 -- to remove drive torque from the drive ratchets (11).
- Drive Gear Pin (36) -- S.F. 3.7 rupture -- to remove drive torque from drive mechanism (4).
- Protrusion of Lock Ratchets (12) -- S.F. 3.8 yield -- failure results in loss of 1 code bit.

7.3 GEAR BACKLASH

The following analysis shows the backlash in the reversing gear mechanism (from the drive pawl to the drive ring) to be 1.1 degrees.

Backlash is defined as the clearance between adjacent teeth of mating gears measured at the common pitch circle. It is, therefore, the amount by which a tooth space exceeds the thickness of the engaging tooth.

Two elements contribute to the backlash between gears; the variation in gear center distance due to manufacturing tolerances, and the normal clearances between teeth to prevent jamming. The former variation is a function of the gear pressure angle while the latter variation is a function of the class of gears.

TABLE III

SUMMARY PIECE PART STRESS – ABORT MODE

Part (Numbers refer to Figure 10)	Material	Stress[a] (psi)	Allowable Stress (psi)	Safety Factor Based on Yielding
Drive Gear (3)	303 SS	8,300	35,000	4.2
Drive Gear Pin (36)	446 SS	23,200	55,000	2.4[b]
Drive Pawl Mechanism (4)	Brass	2,300	51,000	22.2
Drive Pawl (10)	Berylco Nickel 440	22,000	200,000	9.1[c]
Camming Pin (33)	303 SS	4,900	35,000	7.1
Drive Ratchet (11)	303 SS	3,700	35,000	9.5
Lock Ratchet (12)	AM355 SS	48,700	183,000	3.8
Lock Arm (13)	AM355 SS	33,400	183,000	5.5
Lock Pawl (18)	Berylco Nickel 440	21,700	200,000	9.2[d]
Drive Gear Tooth (3)	303 SS	1,900	35,000	18.4
Pinion Tooth (6)	416 SS	29,600	145,000	4.9
Pinion Pin (37)	416 SS	47,000	145,000	3.1[e]

[a] Factor of two applied for dynamic condition.

[b] Drive Gear Pin will rupture prior to yielding of other members -- @ 85,000 psi tensile strength, i.e.,

$$\text{S.F. rupture} \ \frac{85,000}{23,200} = 3.66$$

[c] S.F. Buckling 2.6

[d] S.F. Buckling 3.0 with reverse torque equal to drive torque.

[e] At 190,000 psi tensile strength -

$$\text{S.F. rupture} = \frac{190,000}{47,000} = 4.0$$

The gear train in the reversing mechanism has three pairs of mating gears. The characteristics of each of the gears are given in Table IV.

TABLE IV

GEAR CHARACTERISTICS FOR 20° PRESSURE ANGLE

	No. of Teeth	Pitch Diameter (in)	Gear Class	Maximum Backlash Per Pair (in)
Drive Gear 1	56	0.5833	Prec 3	0.00055
Pinion 1	10	0.1042	Prec 1	0.00146
Pinion 2	10	0.1042	Prec 1	0.00146
Drive Gear 2	56	0.5833	Prec 3	0.00055

The backlash for each mating pair is calculated below.

7.3.1 Drive Gear 1 and Pinion 1

a. Clearance due to 0.001 center distance change (CD). The backlash due to variations in the center distance is approximately equal to the change in center distance multiplied by twice the tangent of the transverse pressure angle.

$$CD = 0.001 \times 2 \times \tan 20^{o} = 0.00073 \text{ in.}$$

b. Normal clearance between teeth (CL).

$$CL = \frac{0.00055 + 0.00146}{2} = 0.001005 \text{ in.}$$

c. Total backlash = CD + CL = 0.001735 in.

7.3.2 Pinion 1 and Pinion 2

a. CD due to 0.001 center distance change = 0.00073

b. Normal clearance between teeth = 0.00146

c. Total = 0.00219 in.

7.3.3 Pinion 2 to Drive Gear 2

a. CD due to 0.001 center distance change = 0.00073

b. Normal clearance between teeth = 0.001005

c. Total = 0.001735

7.3.4 Total Backlash for Mechanism

a. Total linear clearances = 0.001735 + 0.00219 + 0.001735 = 0.00566 in.

b. Angular backlash (θ)

$$\theta = \frac{\text{Linear Distance}}{\pi \times \text{Pitch Dia.}} \times 360$$

$$= \frac{0.00566 \times 360}{\pi \times 0.5833} = 1.11^{\circ}$$

7.4 PHOTOTRANSISTOR OUTPUT - SPECTRONICS SD5443-4

For the SD application at a Radiant Power Input of 10^{-5} watts, the following analysis is used to select the photodetector.

The input fiber/optic bundle has a diameter of 0.045 in. (0.1143). The Photodetector chip diameter is 0.050 in. (0.127 cm). The lens can termination shown in Figure 11 collimates the light output of the fiber bundle, and effectively places the detector chip directly over the fiber/optic cable output.

The Power Input to the detector is:

1.0×10^{-5} watts.

A loss of -3 dB is expected due to coupling losses in the fiber optic/detector interface. The total input power in the "on"state is:

$1.0 \times 10^{-5} (0.5) = 0.5 \times 10^{-5}$ watts

From the Specification sheet for the SD5443-4 its light current output is:

$3.2\ \text{ma}/_{\text{mw}}/_{\text{cm}^2}$

to determine the photocurrent, Irradiance equals

$$H = \frac{P}{A} \quad \text{w/cm}^2$$

$$\frac{0.5 \times 10^{-5}}{\frac{\pi (0.127)^2}{4}} = 39.5 \times 10^{-5} \text{ w/cm}^2 = 0.395 \text{ mw/cm}^2$$

and the photocurrent is:

$$I_p = 3.2\ \text{ma}/_{\text{mw}}/_{\text{cm}^2} \times 0.395 \text{ mw/cm}^2$$

$$= 1.264 \text{ ma}$$

To compensate for the monochromatic source the total photocurrent output is multiplied by a factor of 2.7, making the photocurrent output at 10^{-5} watts input.

$$1.264 \text{ ma} \times 2.7 = 3.413 \text{ ma}$$

The photocurrent for an "off" condition of 10^{-8} watts input is:

$$0.0034 \text{ ma} = 3.4\ \mu\text{a}$$

The total "off" current is the photocurrent plus the "dark current" and for the SD5443-4 is:

$$3.4\ \mu\text{a} + 0.1\ \mu\text{a} = 3.41\ \mu\text{a}$$

Under actual operating conditions, saturated operation of the phototransistor results in excessive rise and fall times which can produce excessive dissipation by causing all power switches to be on simultaneously. Therefore the phototransistor load resistors are selected such that the phototransistors operate in a non-saturated mode.

8.0 SWITCH DRIVER MODEL

8.1 SPECIAL TEST EQUIPMENT

To facilitate functional testing of the Switch Driver, an auxiliary piece of test equipment has been designed and is referred to as the SD Data Generator.

8.1.1 Functional Description

The Data Generator is illustrated in schematic diagram Figure 12. It is comprised of two 32 bit parallel in/serial out shift registers, with presettable inputs, and auxiliary logic to load the preset data and output the coded data on command. There are two controls actuated by push button switches; Load and Start. An external +10 to +12V power supply is required as well as an external pulse generator to provide the necessary timing pulses. The Data Generator provides the capability of generating dual coded pulse trains of from 1 to 32 bits, at a rate determined by the setting of the external pulse generator. These coded outputs can, at the operator's discretion, be either complementary or non-complementary to allow functional testing of both true and dud modes of operation.

Data is loaded by presetting the 64 data switches, access to which is made through the open underside of the Data Generator. Switches are set to logic "1" in "on" position, and logic "0" in the "off" position. Switch settings are changed using a ball point pen to actuate the switch rockers.

The "Load" switch actuates a 300 ms monostable multivibrator Z1 (CD4047A) to produce the load pulse. The Load pulse also clears the pulse counter Z4 (CD4020), and enables the end of cycle flip flop Z2B (CD4027) and the Start switch latch Z5 (CD4043).

The clock input pulse rate is divided by two to produce a 50% duty cycle clock by Z2A (CD4027). The clock output is applied to the clock input of Z2B to synchronize the Start switch and the issuance of data. After data is loaded, the Start switch is depressed, which sets latch Z5 (CD4043). The latch output is applied to the input of the end of cycle flip flop Z2B. The first positive going clock pulse edge following the setting of the latch Z5, sets Z2B and enables Z3B (CD4011) allowing the inverted clock to clock the data shift registers, at the 50% clock cycle point. The clock is inverted once more through Z3A and enables the first data bit output from the generator. When the clock pulse terminates, data is turned off and the next data bit is shifted into the first bit position. The next clock cycle repeats this process until 32 bits have been output, at which time counter Z4 (CD4020) Resets the end of cycle flip flop Z2B, and the Start switch latch Z5. A new cycle is produced by depressing the Load switch, followed by the Start switch.

> Note: The input clock pulse generator must operate at 2 x the desired data rate output: (i.e., a 40 Hz output rate, requires an 80 Hz clock pulse input to produce a 40 Hz 50% duty cycle output).

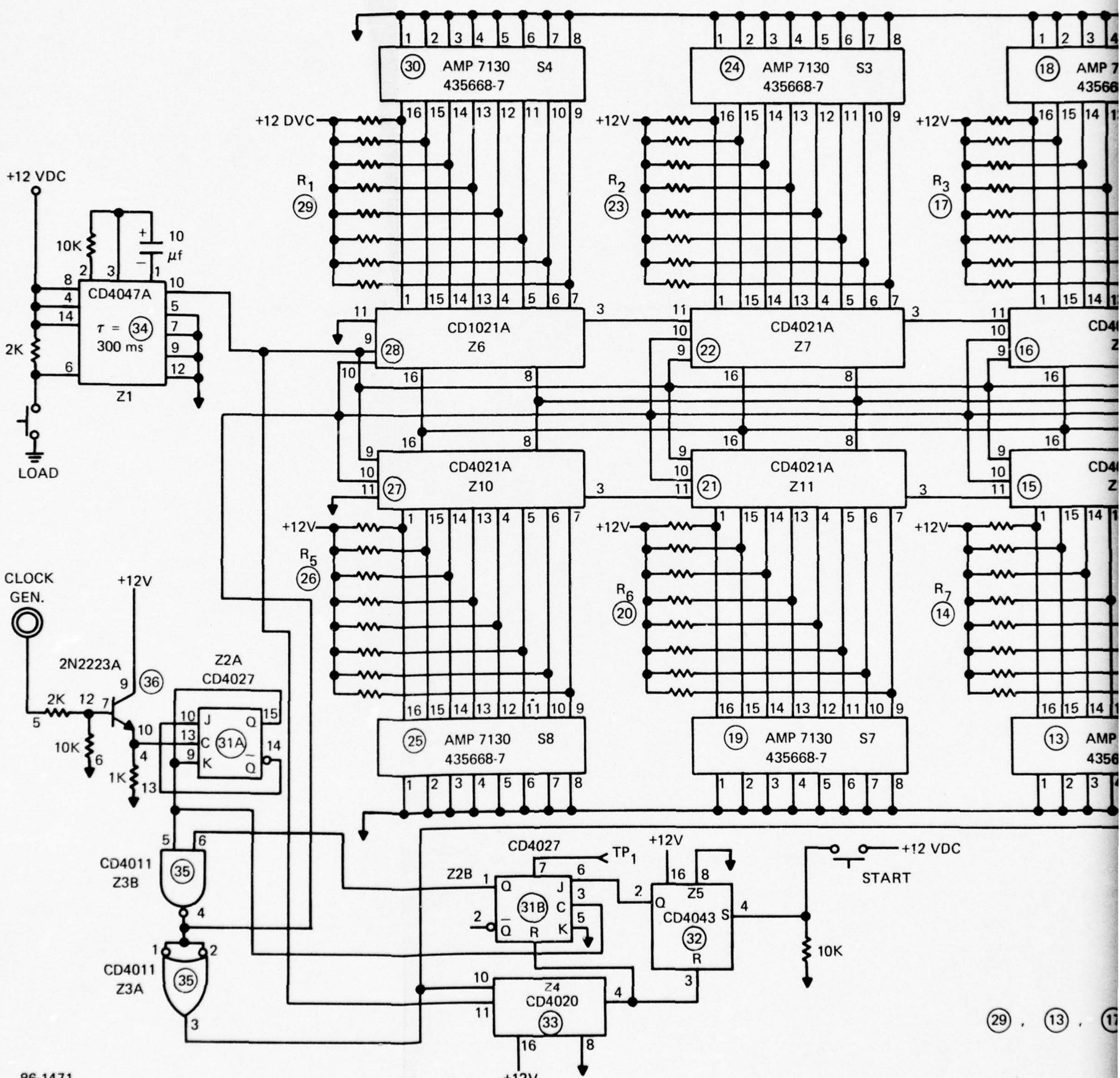
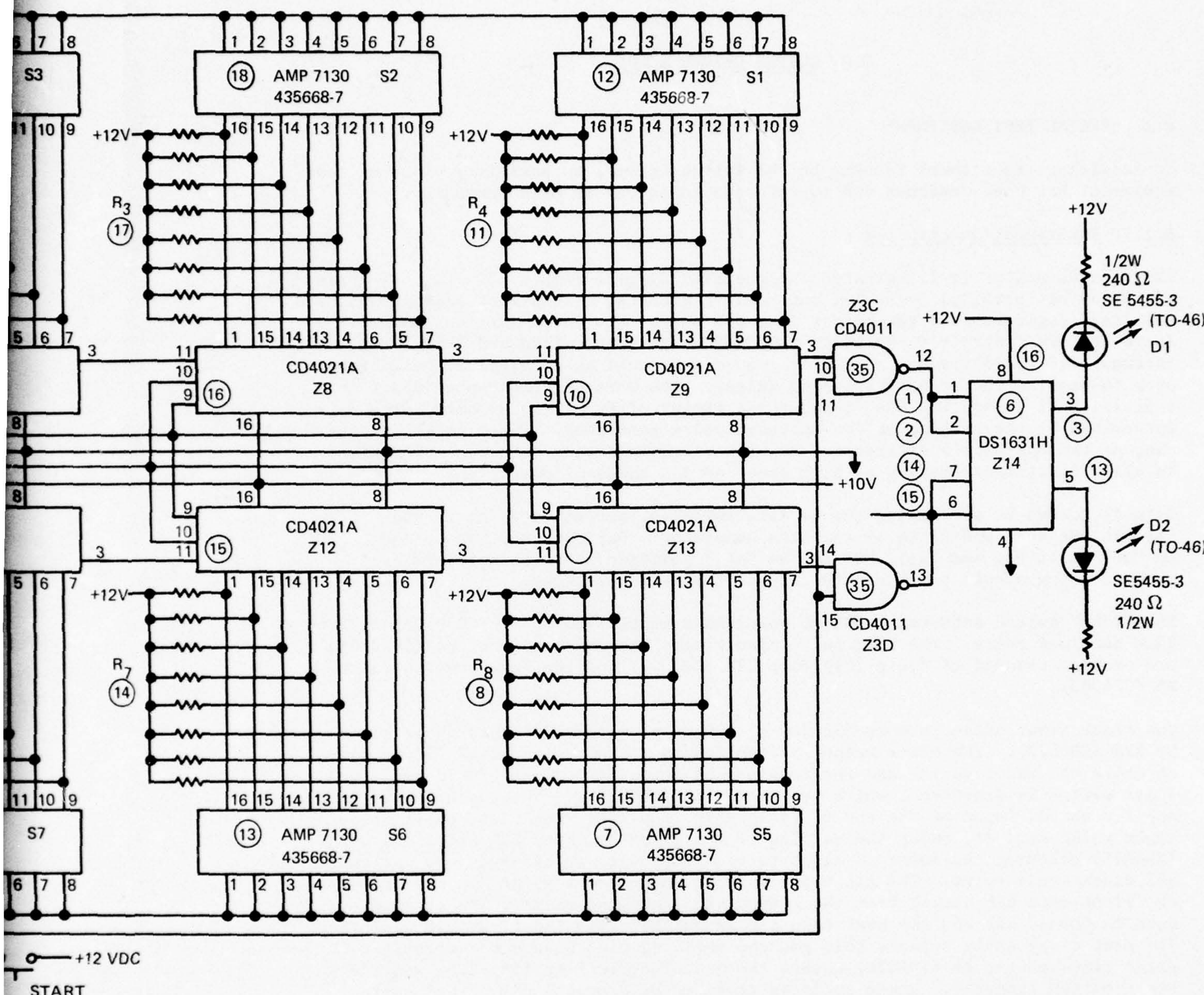


Figure 12 DATA GENERATOR



29 , 13 , 17 , 11 , 7 , 14 , 20 , 26 BECKMAN 898-3-R-22K

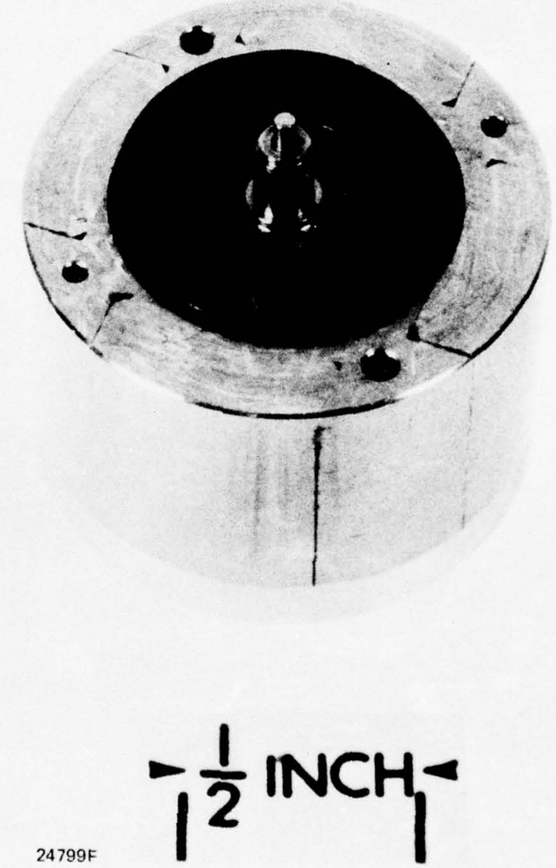
Figure 12 DATA GENERATOR

To generate less than 32 bits, all the bit switches following the desired bits are set to logic "0", or "off", on both channels. Z14 (DS1631H) is the current driver for the LED's, Spectronics SD5455-3.

Controls and input terminals to the Data Generator are clearly marked for function on the face of the unit.

8.2 PHOTOGRAPHS

The following photographs (Figures 13 through 19) show the major piece part components of the Switch Driver and the assembled model with the special test equipment.



24799F

Figure 13 STANDARD OFF-THE-SHELF TORQUE MOTOR

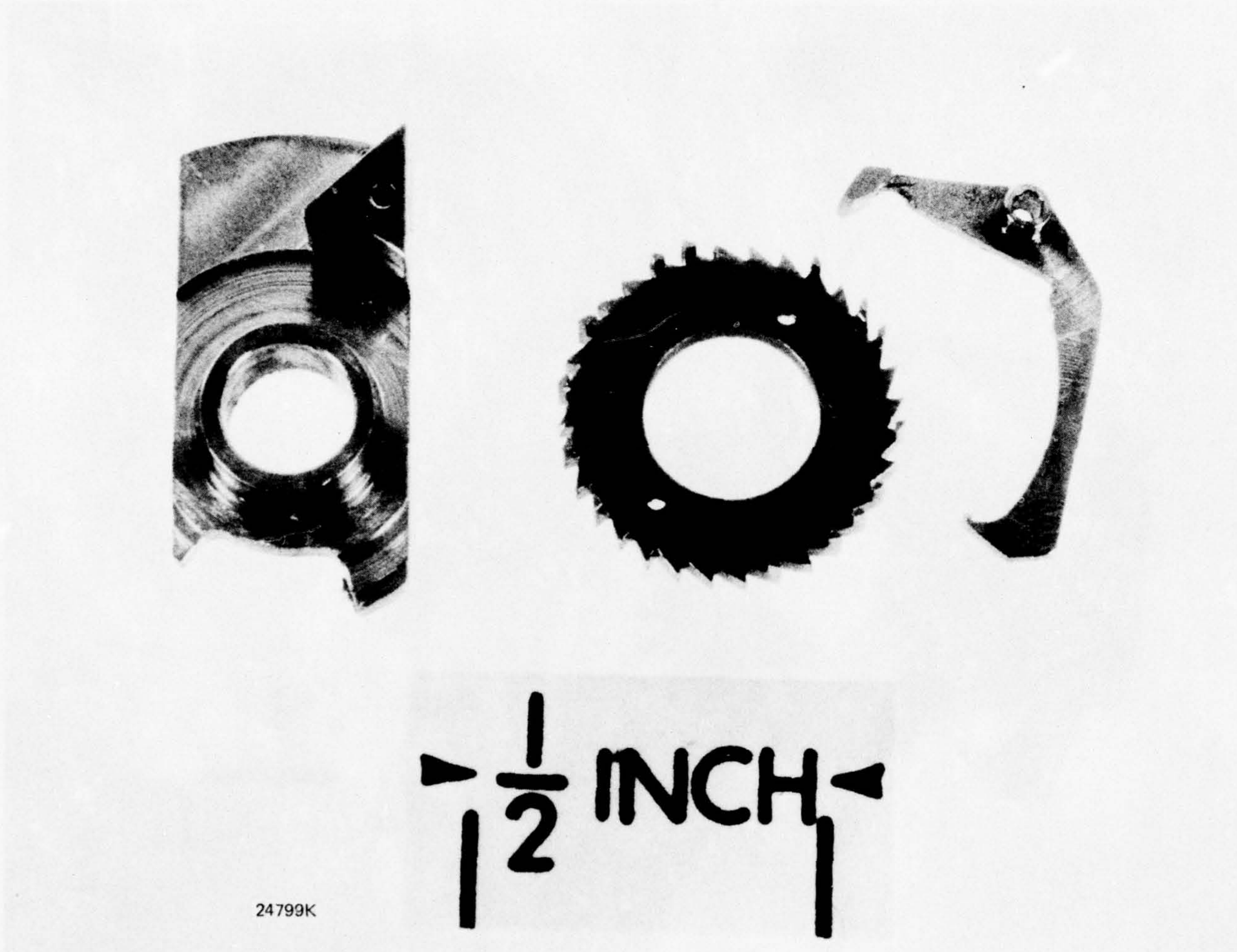


Figure 14 ABORT RATCHET, LOCK ARM AND DRIVE PAWL

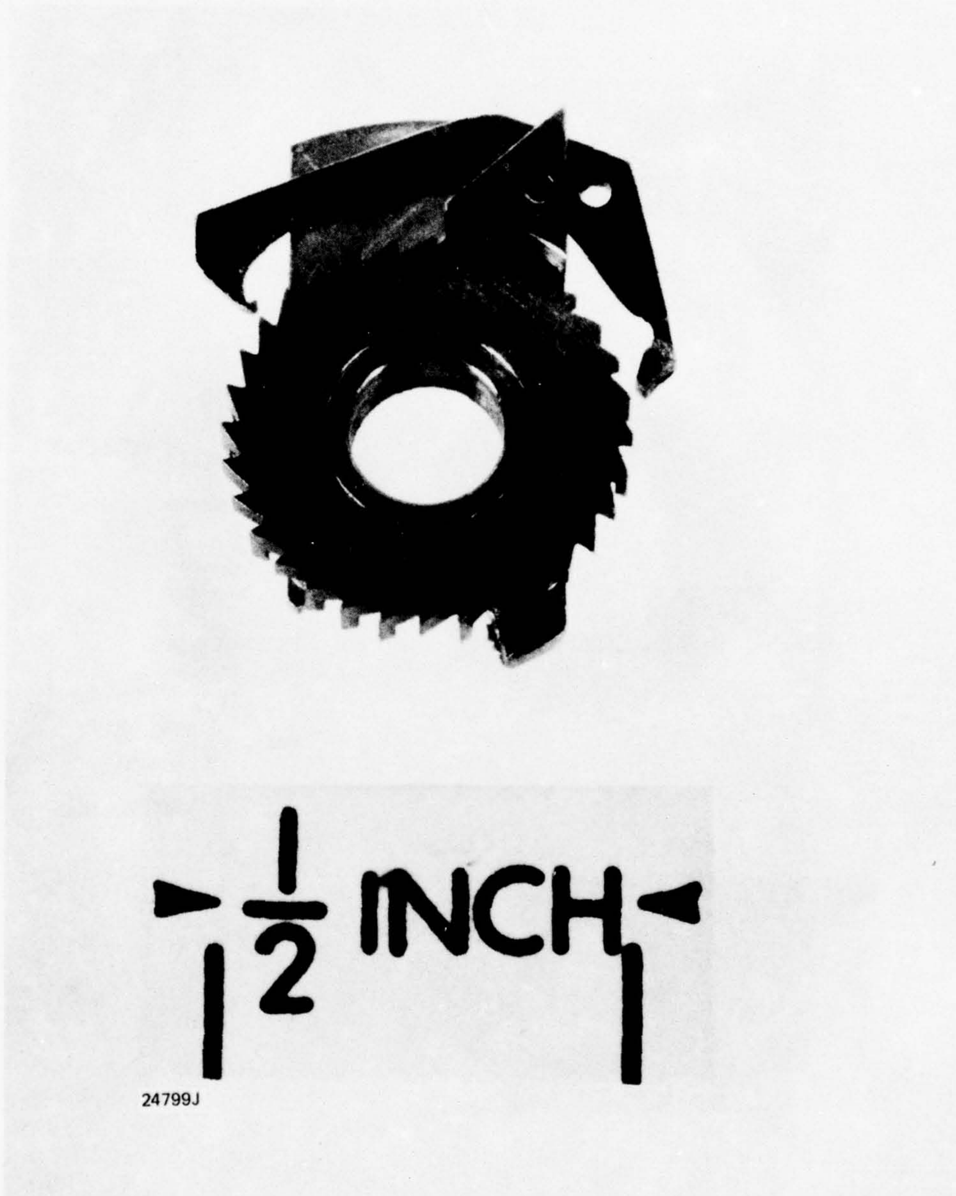


Figure 15 RELATIVE POSITION OF COMPONENTS OF FIGURE 14

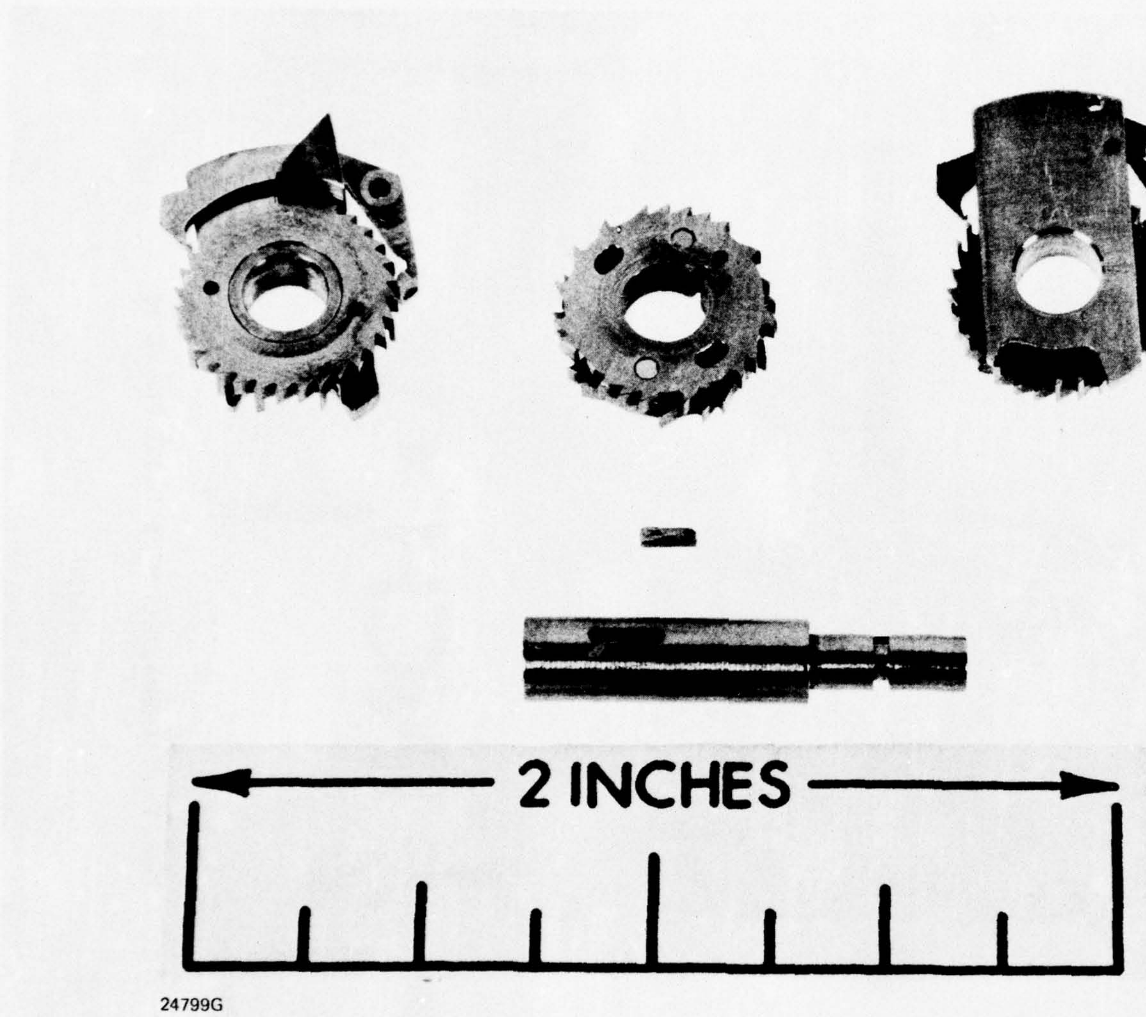


Figure 16 MAJOR CODE MECHANISM COMPONENTS

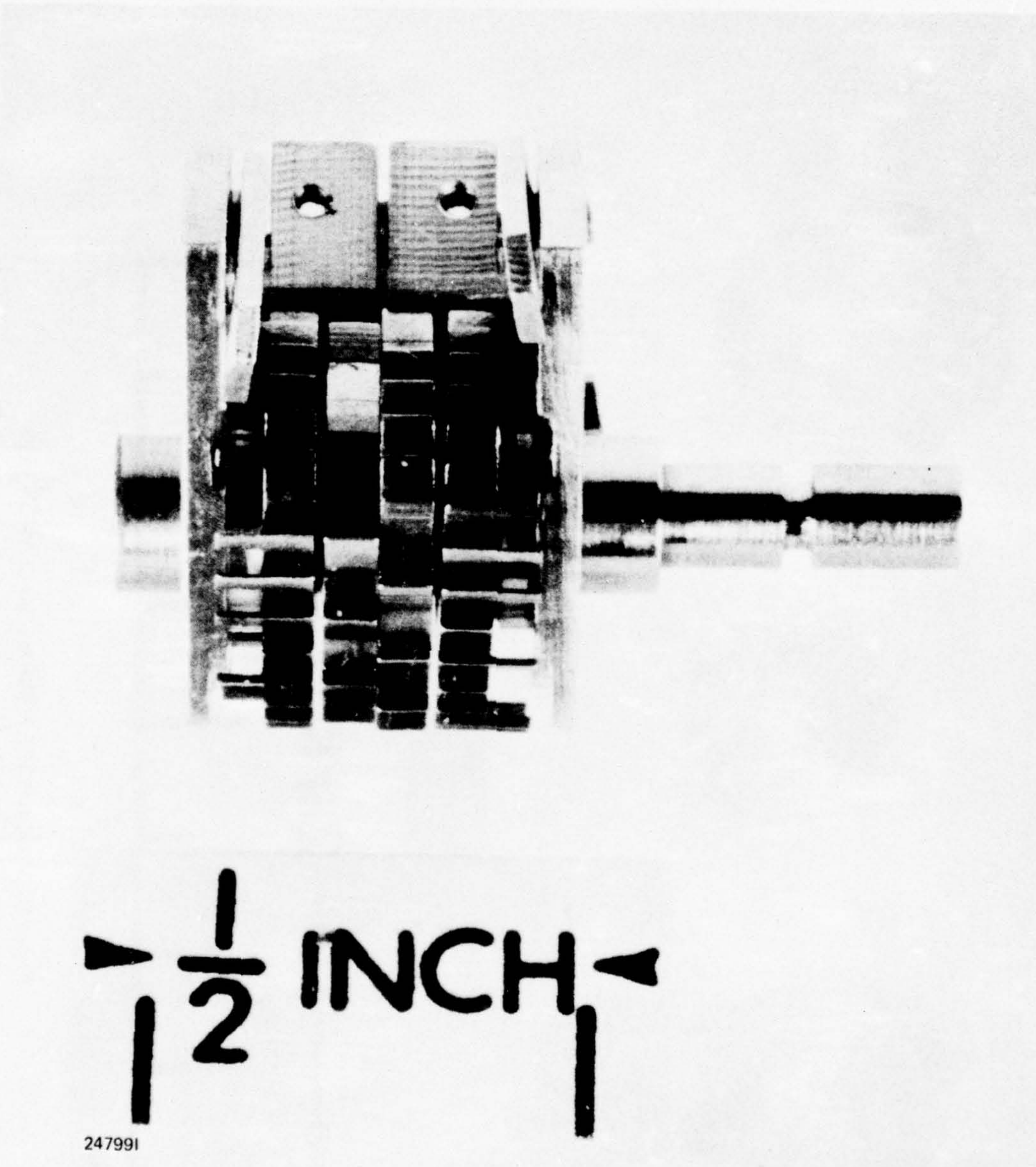


Figure 17 ASSEMBLY OF COMPONENTS OF FIGURE 16

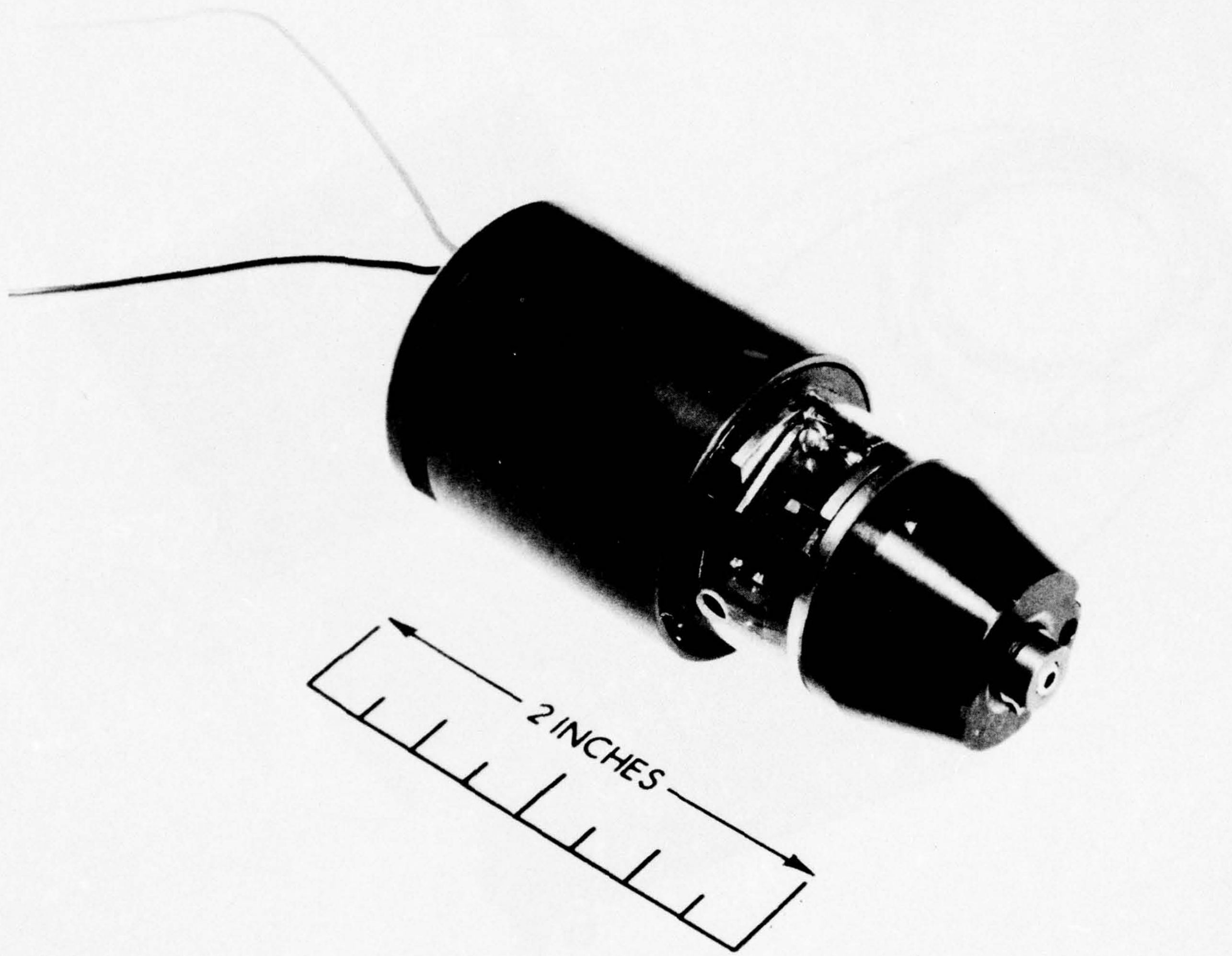


Figure 18 SWITCH DRIVER

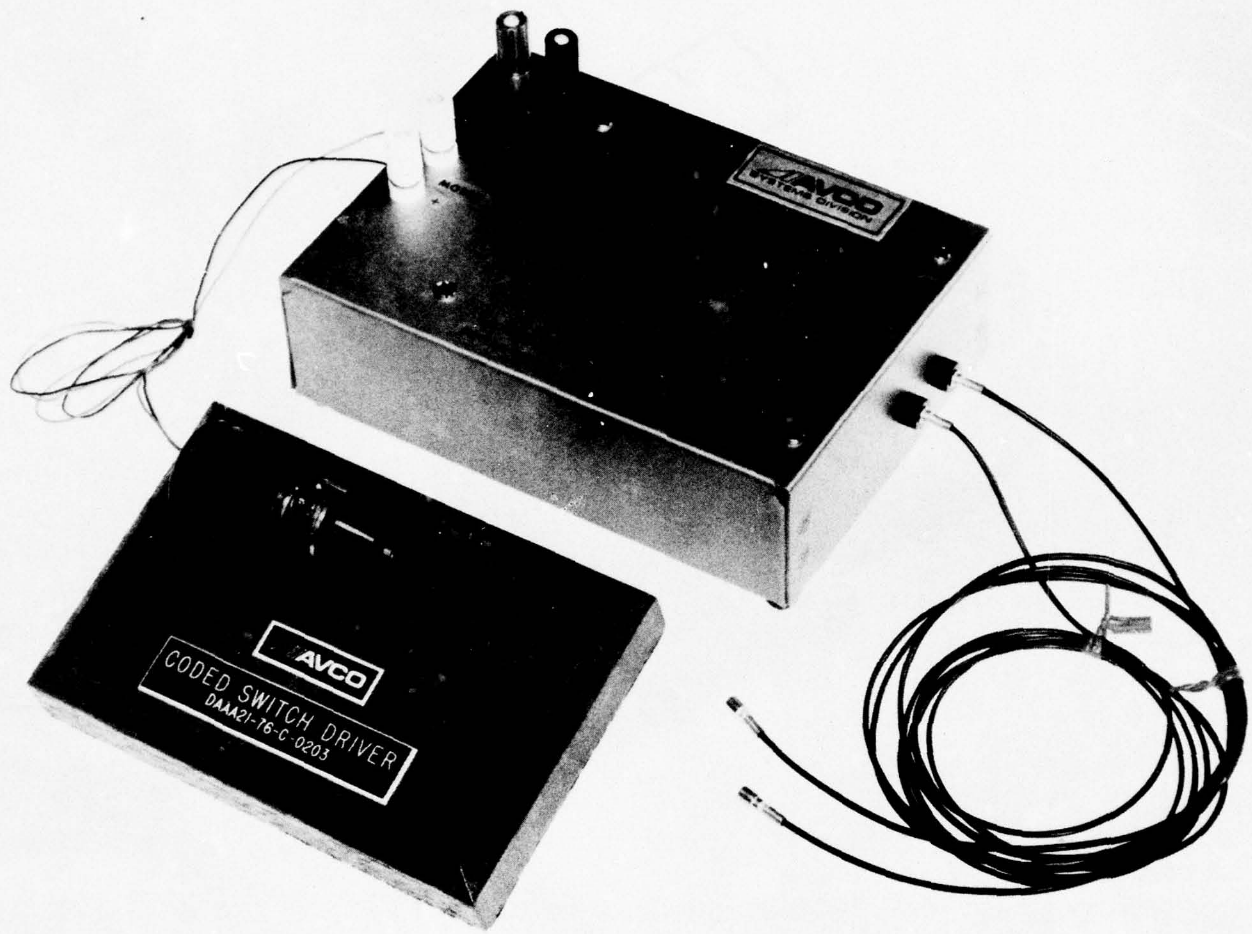


Figure 19 SWITCH DRIVER AND SPECIAL TEST EQUIPMENT

9.0 CODE

As previously mentioned, the code is not constrained and can be any desired binary combination. The code for the first 20 bits of the Switch Driver model was selected using a random number table. Odd numbers were assigned a "1" and even numbers a "0". The drive ratchets were then machined so that a "1" corresponded to a left drive pawl index (clockwise rotation of torquer) and a "0" to a right drive pawl index (counterclockwise rotation of torquer). The complete code is presented in Table V.

TABLE V

SWITCH DRIVER MODEL CODE

Verifying Code		Drive		Reset	
Bit	Code	Bit	Code	Bit	Code
1	1	21	1	29	0
2	0	22	0	30	0
3	1	23	1	31	0
4	1	24	0	32	0
5	1	25	1		
6	0	26	0		
7	1	27	1		
8	0	28	0		
9	0				
10	1				
11	1				
12	0				
13	1				
14	0				
15	0				
16	0				
17	1				
18	1				
19	0				
20	0				

10.0 FUNCTIONAL TEST RESULTS

The driver electronics circuit was breadboarded per the schematic of Figure 9. Initial operation had both phtotransistors operating saturated. Rise time and fall time were greatly in excess of acceptable limits, causing all transistor switches to be "on" simultaneously at the beginning and end of each pulse. Resistors R1, R2, R3, R4, R5, and R6 were changed to keep the phototransistors out of saturation, and the rise and fall times were restored to 10 microseconds or less. The base pull up resistors on Q7 and Q10 were increased to 10K from 300 ohms to reduce power consumption, and Resistors R17 and R18 were added to allow the collector capacitances to discharge when all power switches are in the "off" condition. These modifications resulted in successful performance of the optical and electronics driver modules.

The mechanical driver mechanism was fabricated to the configuration of the Appendix A drawings. The mechanism was manually functioned to check out normal, abort and reset operation modes. After successful operation was achieved, the mechanism was then connected with the optical/electronics driver module. The SD data generator described in Figure 12 was connected to the optical/electronics module with 2 fiber optic bundles with lens terminations. This was used as a source for the optical signals. The following functional tests were then conducted:

TEST RUN 1

The SD was operated in a semi automatic mode using the data generator push buttons. This functioning verified:

1. The device responded to the correct design code.
2. Correct clutch operating sequence.
3. Resettability from normal arm condition.
4. Proper response to incorrect codes (i.e., abort mode).
5. Resettability from abort condition.

TEST RUN 2

The SD was operated in an automatic mode using the data generator with an external variable frequency pulse generator.

Device response to correct design code, correct clutch operating sequence and response to incorrect code was verified at each of the following frequencies:

5 Hz (5.6 seconds total cycle time)

10 Hz (2.3 seconds total cycle time)

30 Hz (0.933) second total cycle time)

60 Hz (0.467 seconds total cycle time)

11.0 CONCLUSION

The Switch Driver, represented by the configuration of Figure 10 and the details delineated in Appendix A, will meet the design requirements of Section 5.0 and contain the design features of Section 6.0 including a 60 Hz response capability.

11.0 CONCLUSION

The Switch Driver, represented by the configuration of Figure 10 and the details delineated in Appendix A, will meet the design requirements of Section 5.0 and contain the design features of Section 6.0 including a 60 Hz response capability.

12.0 RECOMMENDATIONS

The described concept should be further developed to:

- optimize the code mechanism design and definition.
- develop miniaturized optics and electronics.
- optimize torque motor.
- demonstrate performance in the normal and abnormal environments associated with weapon systems stockpile to target sequence.

APPENDIX A

DETAIL DRAWINGS OF THE BREADBOARD MODEL

DFT GROUP LDR		S 5 2 0	DATE	SEPT 3, 76	SHEET	1 OF 2
JOB NUMBER	T151-F300-003	DRAWING TRANSMITTAL AND	ENG.	M. WOLF	SECT	F310
[redacted]	D287-AA11-A00	HISTORY SHEET	REL SCHED DOC			

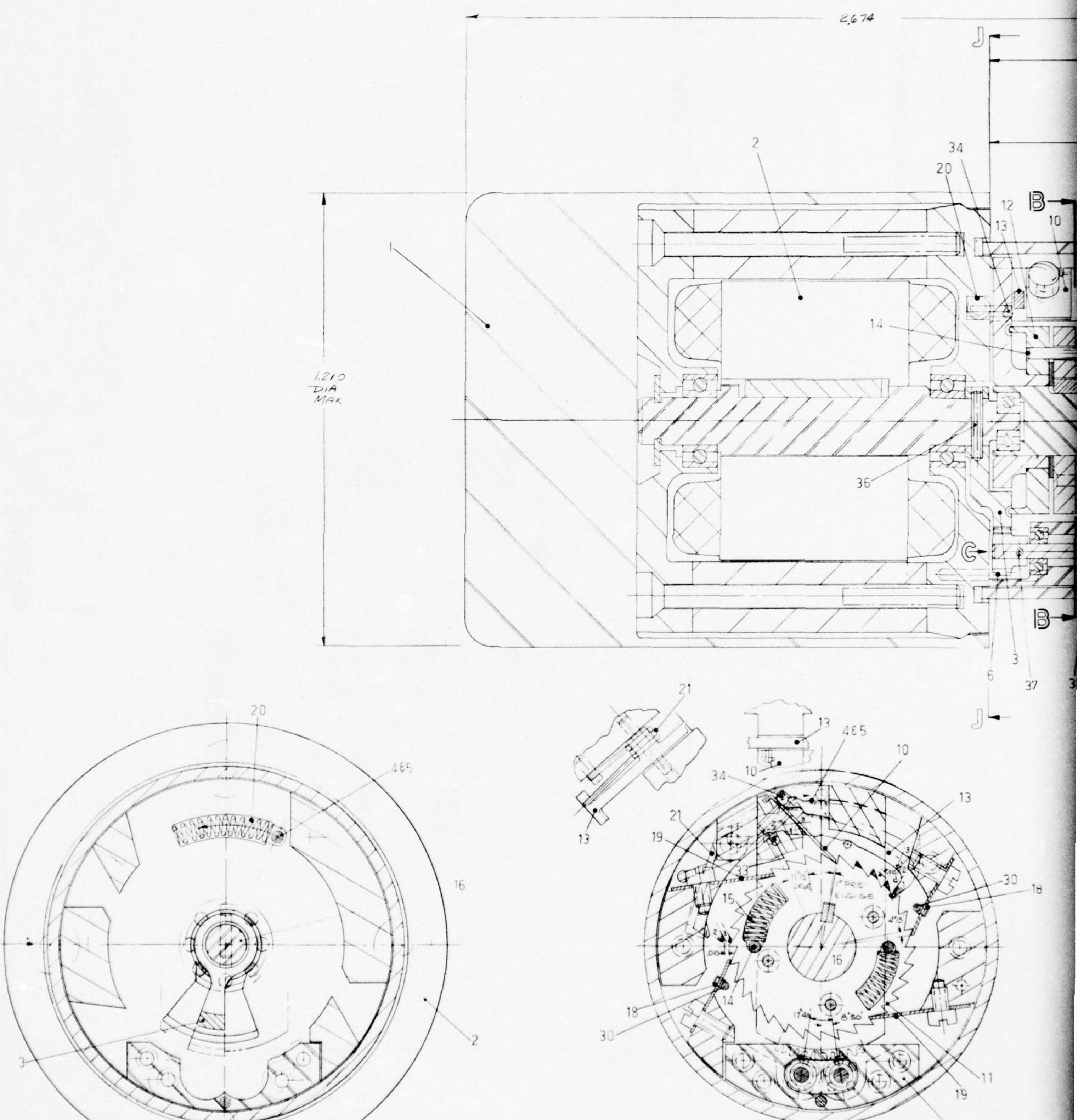
NEXT ASSY NO.	REV	TITLE	PROGRAM USED ON
		SWITCH DRIVER	

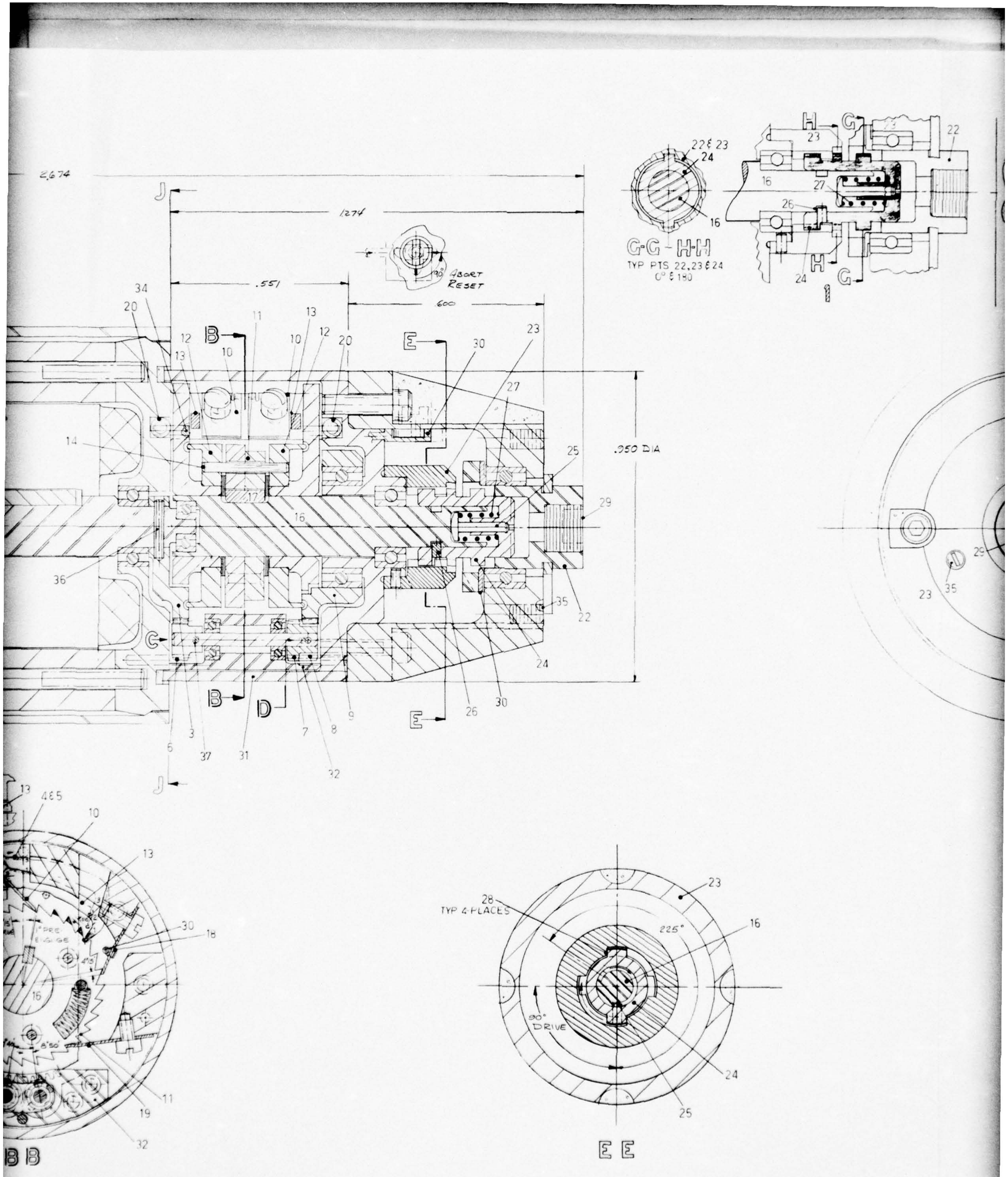
1	2	3	4	5	6	7	8	DWG NO.	TITLE	DRWN	CHK				REMARKS AND REF DATA
								LA 23216	SWITCH DRIVER	✓	✓				
								EX 23251	RATCHET WHEEL BLK	✓	✓				
								EX 23252	END PLATE	✓	✓				
								EX 23253	SHAFT TORQUE MOTOR	✓	✓				
								EX 23254	THRUST MOTOR SHAFT KEY	✓	✓				
								EX 23255	DRIVE GEAR	✓	✓				
								EX 23256	MAIN SHAFT	✓	✓				
								EX 23257	SPRING THRUST PIN	✓	✓				
								EX 23258	LOCK ARM	✓	✓				
								EX 23259	MAIN SHAFT KEY	✓	✓				
								EX 23260	BASE SUPPORT	✓	✓				
								EX 23261	PAWL No 1	✓	✓				
								EX 23262	PAWL No 2	✓	✓				
								EX 23263	INNER COVER	✓	✓				
								EX 23264	LOCK RING	✓	✓				
								EX 23265	CLUTCH	✓	✓				
								EX 23266	OUTPUT SHAFT	✓	✓				
								EX 23267	COVER	✓	✓				
								EX 23268	DRIVE RATCHET	✓	✓				
								EX 23269	MOTOR COVER	✓	✓				
								EX 23270	SLEEVE WASHER	✓	✓				
								EX 23271	GEAR	✓	✓				
								EX 23272	DRIVE PAWL	✓	✓				
								EX 23273	FULL PAWL	✓	✓				
								EX 23274	HALF PAWL	✓	✓				

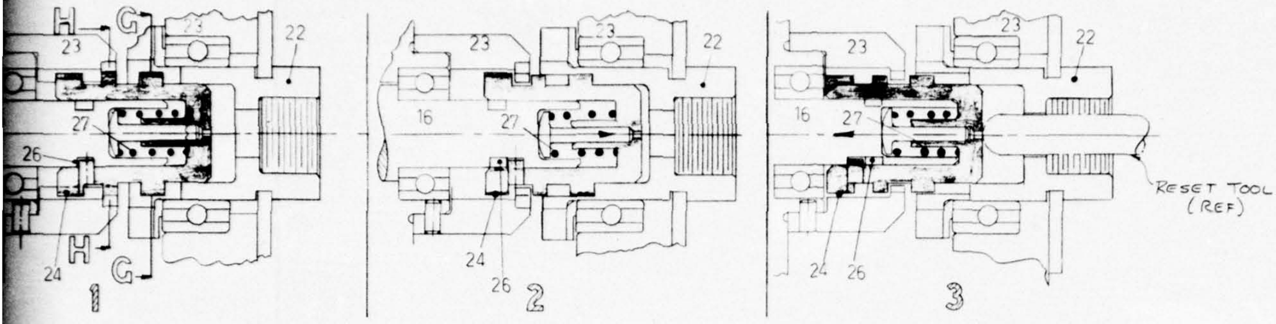
DFT GROUP LDR		S 5 2 0	DATE	SEPT 3,76	SHEET	2 OF 2
JOB NUMBER	T151-F300-003	DRAWING TRANSMITTAL AND	ENG.	M WOLF	SECT	E310
[redacted]	D287-AA11-A00	HISTORY SHEET	REL SCHED DOC			

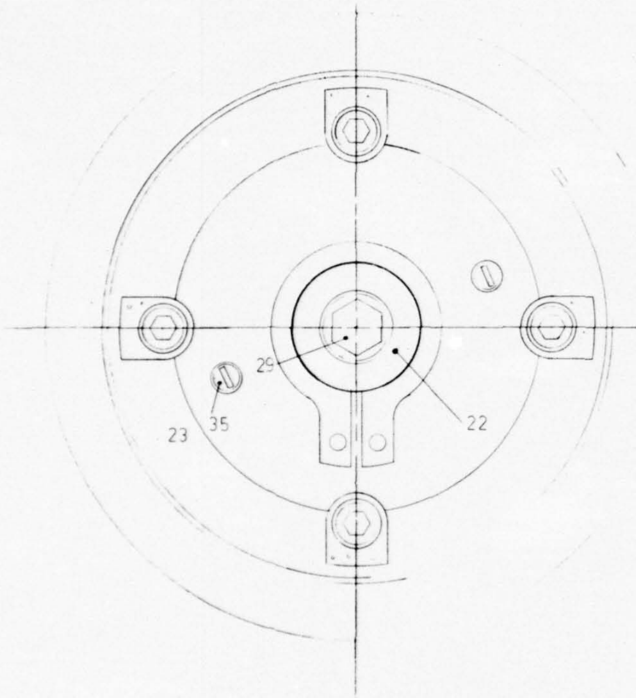
NEXT ASSY NO.	REV	TITLE	PROGRAM USED ON
		SWITCH DRIVER	

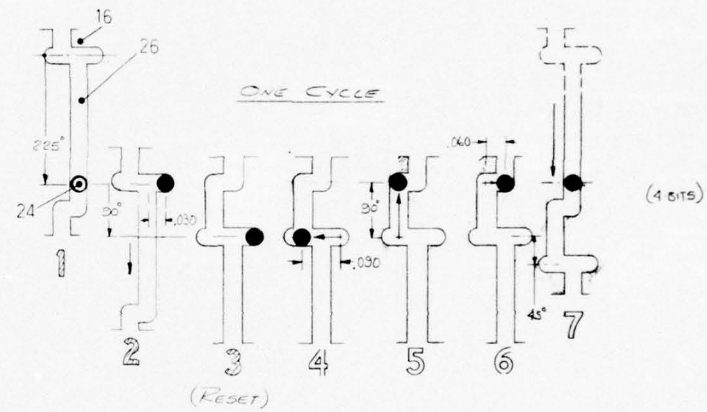
DWG NO.	TITLE	DRWN	CHK				REMARKS AND REF DATA
EX-23275	PINNION ASSEMBLY	✓	✓				
EX-23276	PINNION	✓	✓				
EX-23277	CAGE ASSEMBLY	✓	✓				
EX-23278	PINNION	✓	✓				
EX-23279	BLOCK BEARING	✓	✓				
EX-23280	SECTOR GEAR	✓	✓				
EX-23281	THRUST WASHER	NOT	REQ'D				
EX-23282	WINDOW	✓	✓				
EX-23283	GASKET	NOT	REQ'D				
EX23284	RATCHET ASSY	✓	✓				
EX23285	LOCK RATCHET	✓	✓				
EX23286	RESET PLUG	✓	✓				
EX23287	TORSION SPRING	✓	✓				

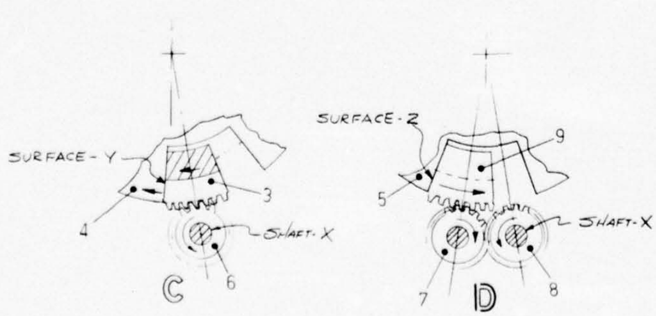

2.674
1.210 DIA MAX
J
B
C
1
2
3
6
10
12
13
14
20
34
36
37
4&5
11
15
16
18
19
21
30
32
33
1° PRE ENGAGE
J-J
B B


2.674
1.274
.551
.600
.950 DIA
90° ABORT
RESET
G-G H-H
TYP PTS 22,23 & 24
0° & 180
28
TYP 4 PLACES
225°
90°
DRIVE
E E
B B
1° PRE-
ENGAGE









1. OPTICAL/ELECTRONICS MODULE
2. TORQUER
3. DRIVE GEAR
4. DRIVE PAWL #1
5. DRIVE PAWL #2
6. PINION
7. PINION
8. PINION
9. DRIVE RING
10. DRIVE PAWLS
11. DRIVE RATCHET
12. LOCK RATCHETS
13. LOCK ARMS
14. TRANSFER PINS
15. SPRING
16. MAIN SHAFT
17. KEY
18. LOCKING PAWLS
19. LOCKING PAWLS
20. RETURN SPRING
21. TORSION SPRING
22. OUTPUT SHAFT
23. STRUCTURE
24. CLUTCH
25. GUIDE PIN
26. CAM TRACK
27. CLUTCH SPRING
28. STOP
29. RESET PLUG
30. THRUST WASHER
31. WINDOW
32. BEARING BLOCK
33. CAMMING PIN
34. LIMIT PIN
35. RESET/ACCESS SCREW
36. DRIVE GEAR PIN
37. PINION PIN

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.

LIST OF PARTS

UNLESS OTHERWISE SPECIFIED TOLERANCE AND DRAWING INTERPRETATION PER D143

MACHINED ANGLES

SHEET METAL BEND ANGLES

SURFACE ROUGHNESS √

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS

TITLE: SWITCH DRIVER

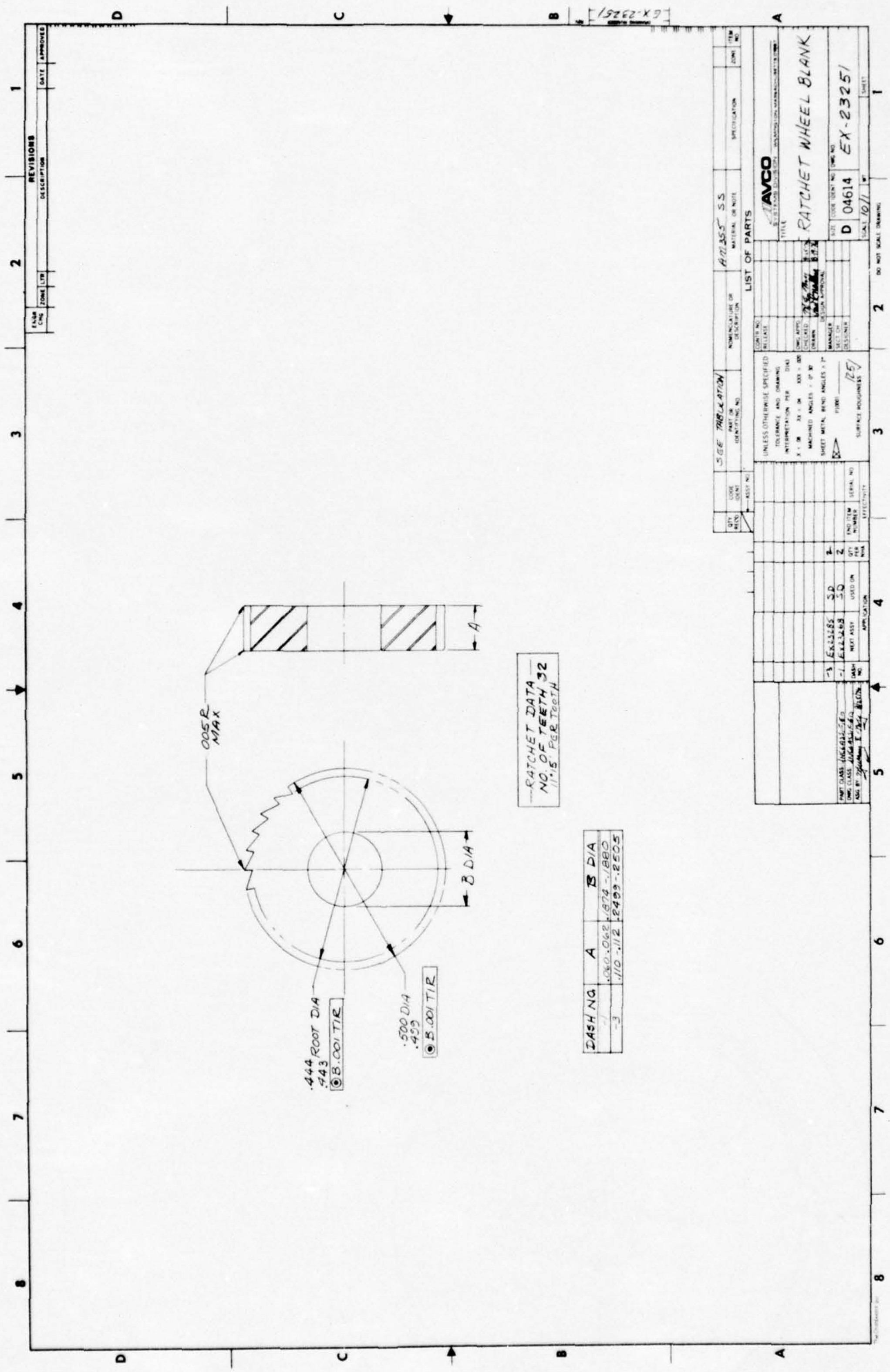
SIZE | CODE IDENT NO. 04614 | DWG NO. LA-23216

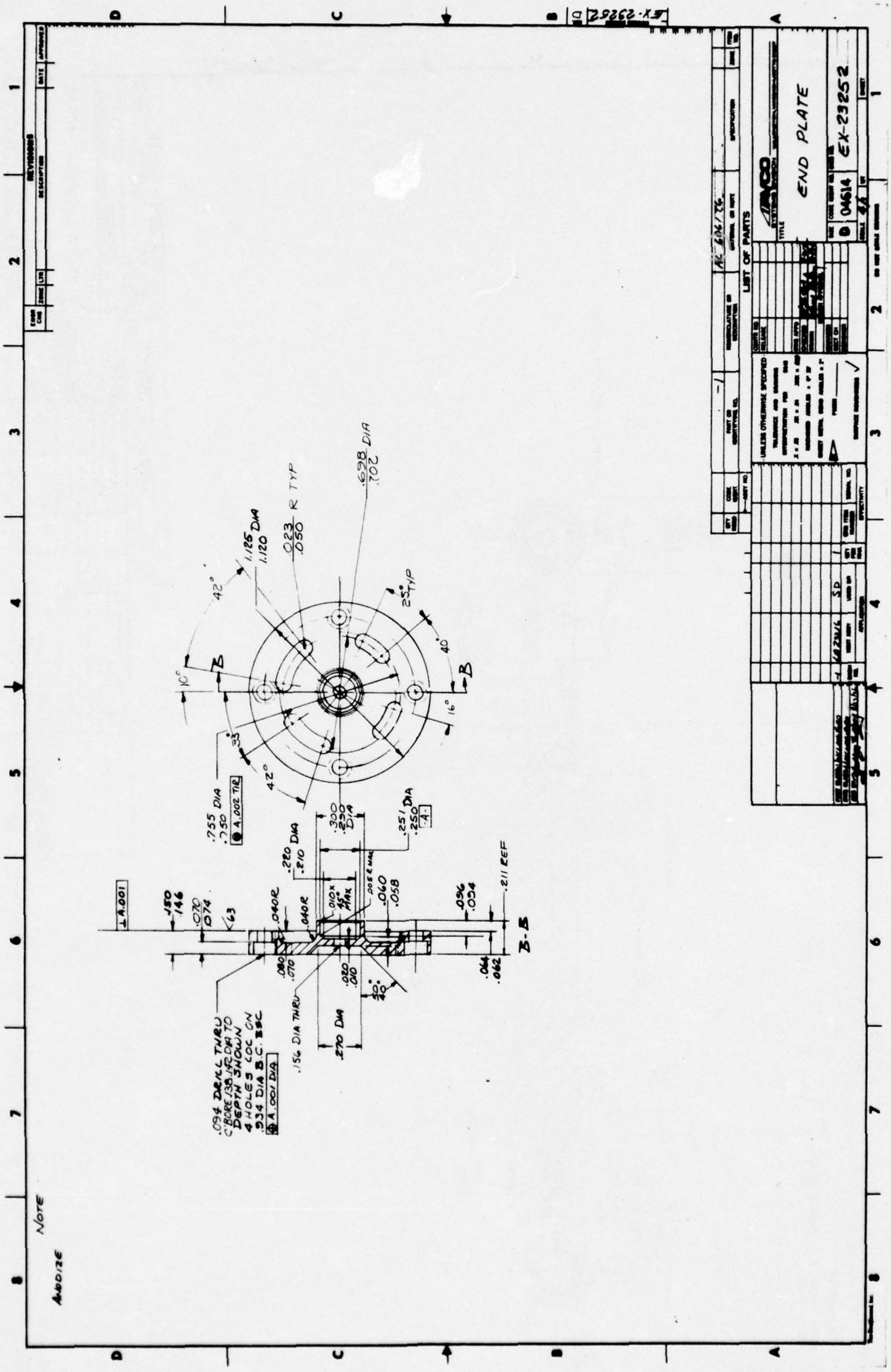
SCALE | WT | SHEET

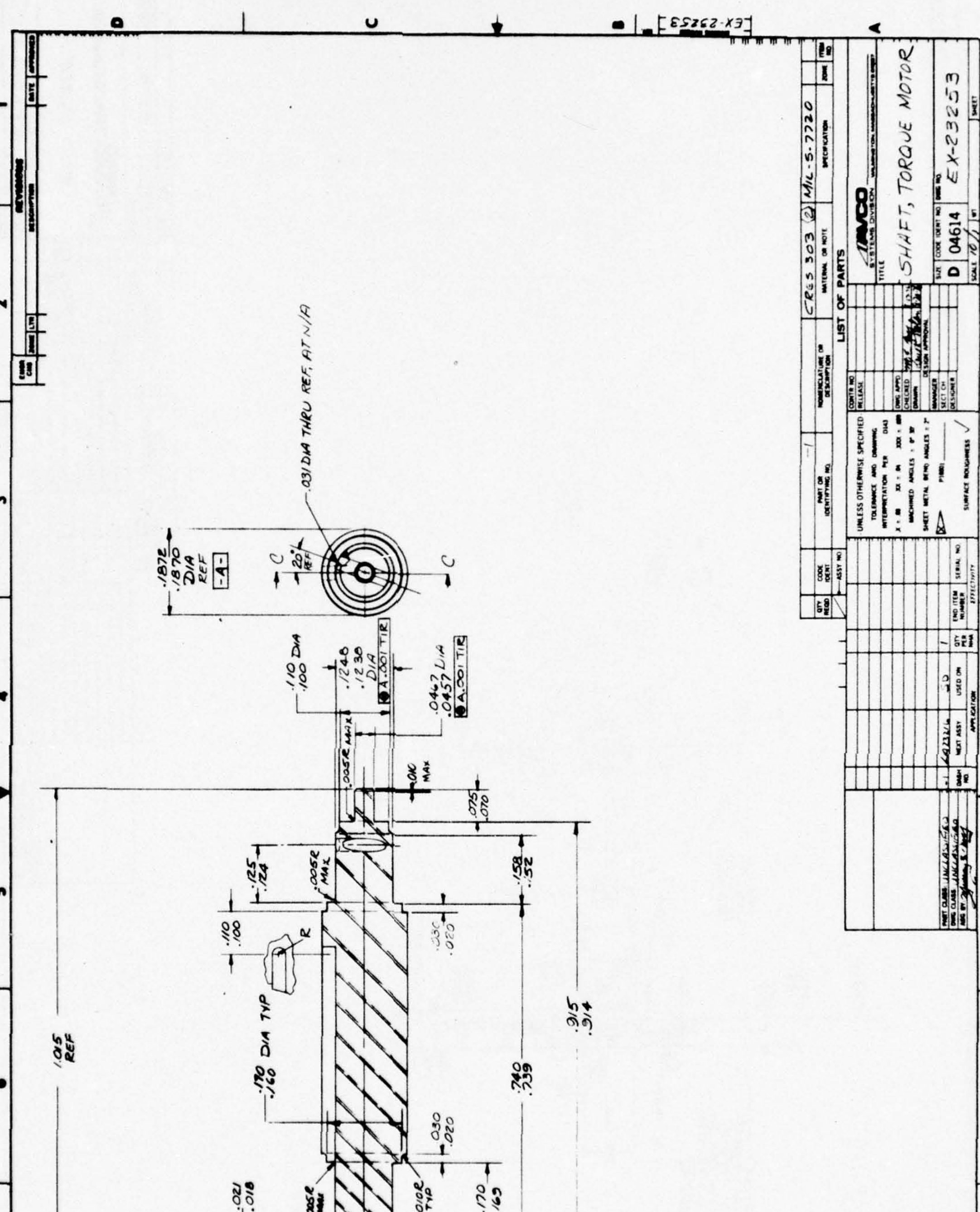
PART CLASS | DWG CLASS | ASG BY | DASH NO. | NEXT ASSY | USED ON | APPLICATION | QTY PER NHA | END ITEM NUMBER | SERIAL NO. | EFFECTIVITY

CONTR NO. | RELEASE | DWG APPD | CHECKED | DRAWN | DESIGN APPROVAL | MANAGER | SECT CH | DESIGNER

3


RATCHET WHEEL BLANK
EX-23251
AVCO
D 04614
LIST OF PARTS
AM355 SS
SEE TABULATION
REVISIONS
.005R MAX
RATCHET DATA
NO. OF TEETH 32
A
B DIA
.444 ROOT DIA .443
B .001 TIR
.500 DIA .499
B .001 TIR
DASH NO. A B DIA
-1 .060-.062 .1874-.1880
-3 .110-.112 .2499-.2505
DO NOT SCALE DRAWING


END PLATE
EX-23252
LIST OF PARTS
NOTE
ANODIZE
B-B



NOTES
1 PASSIVATE
2 MAKE FROM PIC DESIGN CORP NO. A2-10
.0635
.0645
.0625
.0615
.005R MAX TYP
.098
.095 DIA
.1248
.1238 DIA
.010 X 45°
.042
.040
.021
.018
.005R MAX
.010R TYP
.170
.169
.030
.020
.170
.160 DIA TYP
1.015 REF
.740
.739
.915
.914
.110
.100
R
.125
.124
.005R MAX
.158
.152
.075
.070
.06R MAX
.110 DIA
.100
.1248
.1238
DIA
.0467 DIA
.0457
.1872
.1870
DIA
REF
-A-
.201 REF
.031 DIA THRU REF, AT N/A
C
CRES 303 (2) MIL-S-7720
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
SURFACE ROUGHNESS
AVCO SYSTEMS DIVISION
SHAFT, TORQUE MOTOR
D 04614 EX-23253
SCALE 10/1
DO NOT SCALE DRAWING
EX-23253

NOTES

PASSIVATE

ENGR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

LIST OF PARTS

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
		-1		303 CRES			

ASSY NO.

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	LA23216	S D	1		

APPLICATION — EFFECTIVITY

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ABS BY: [signature]

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 .XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001
SURFACE ROUGHNESS √

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE TORQUE MOTOR SHAFT KEY

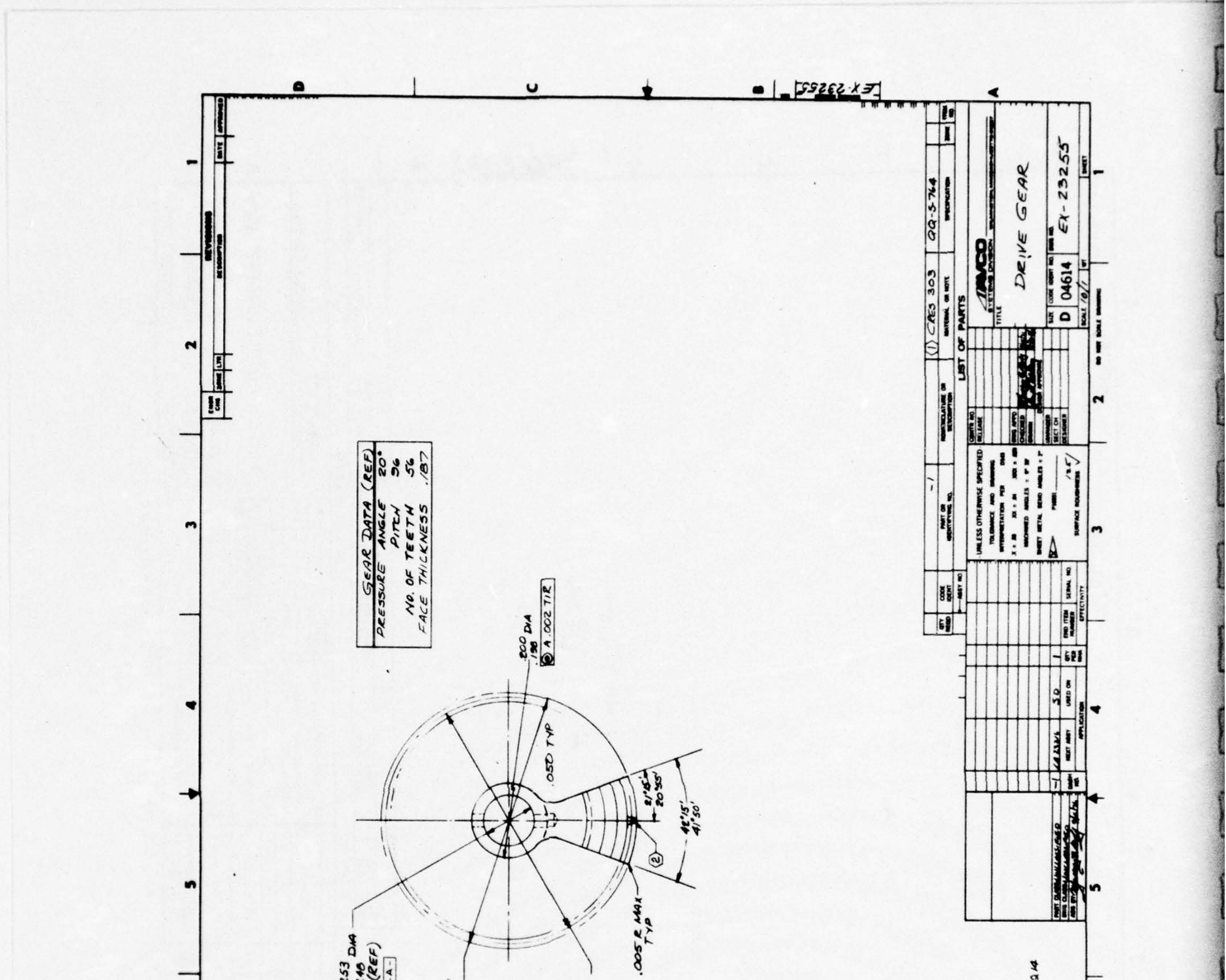
SIZE C | CODE IDENT NO. 04614 | DWG NO. EX-23254

SCALE 20/1 | WT | SHEET

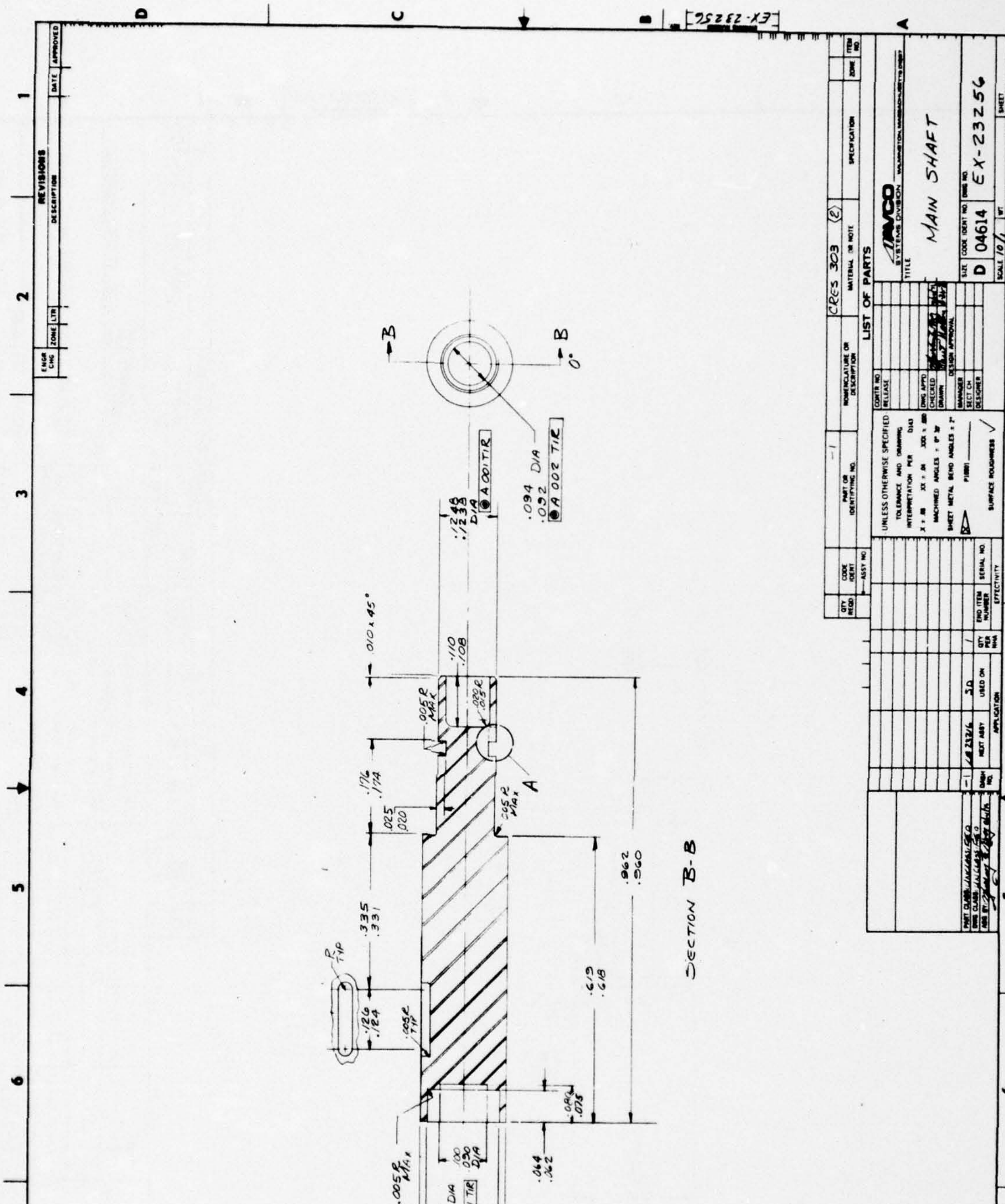
DO NOT SCALE DRAWING

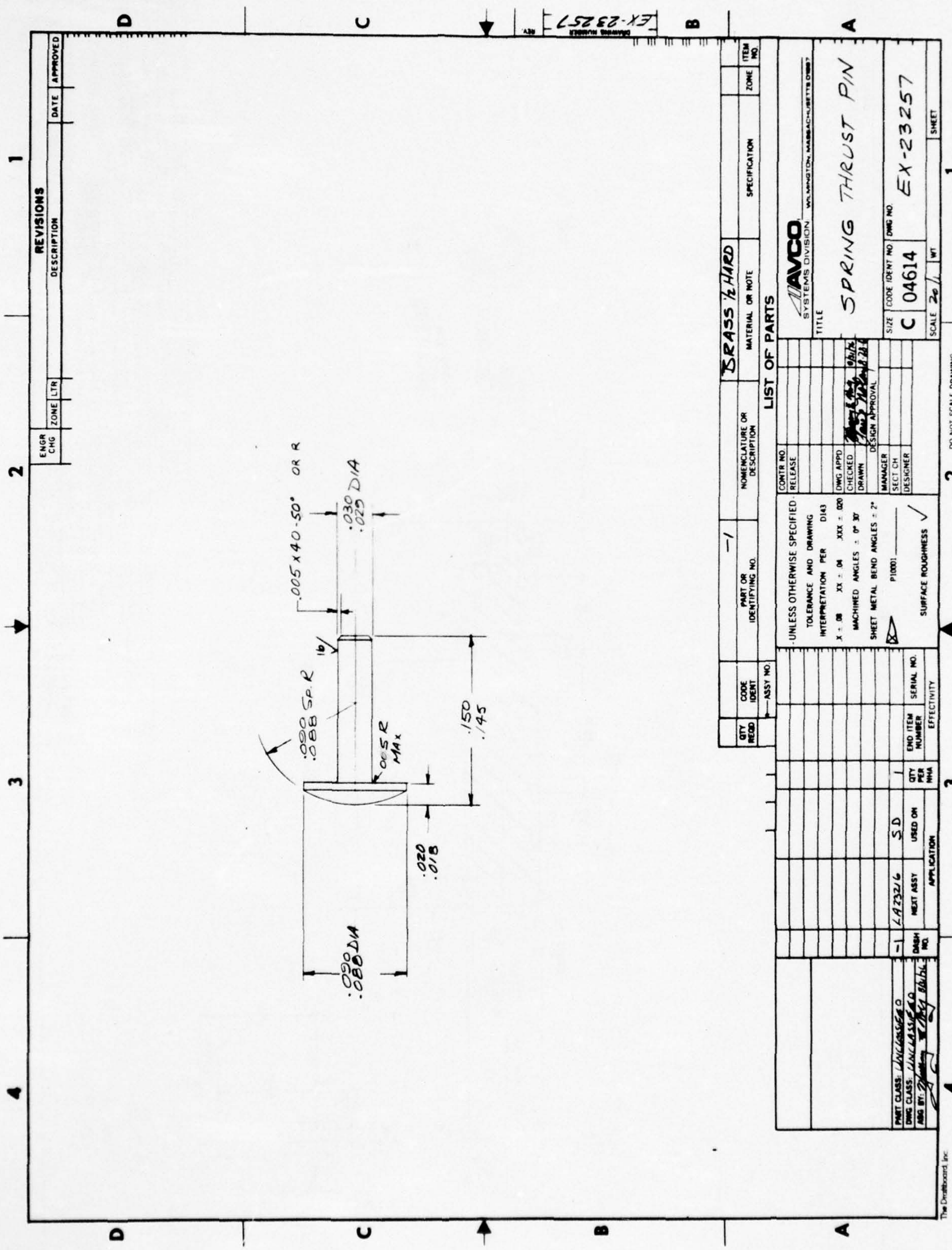
EX-23254

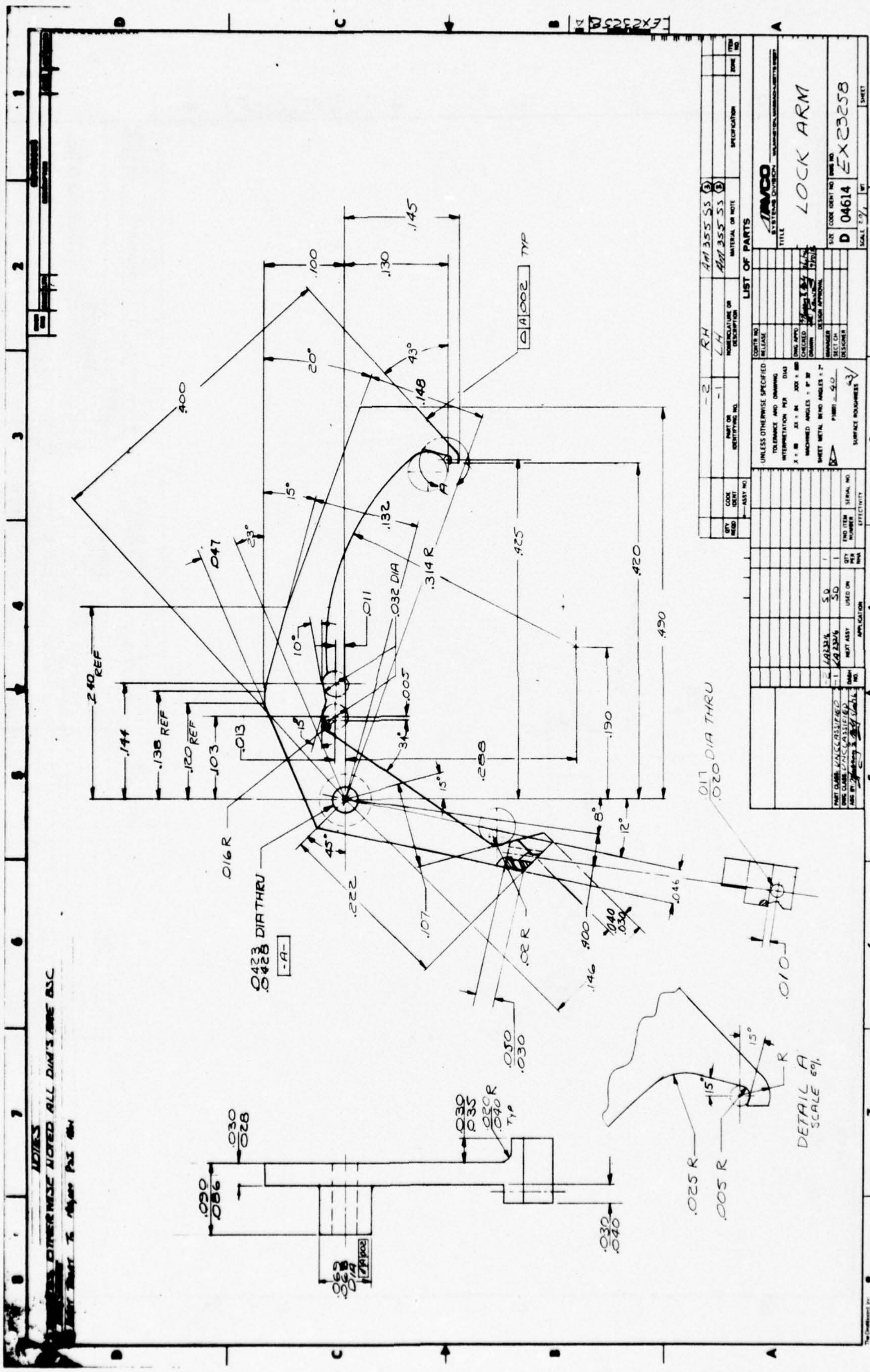
The Draftboard Inc

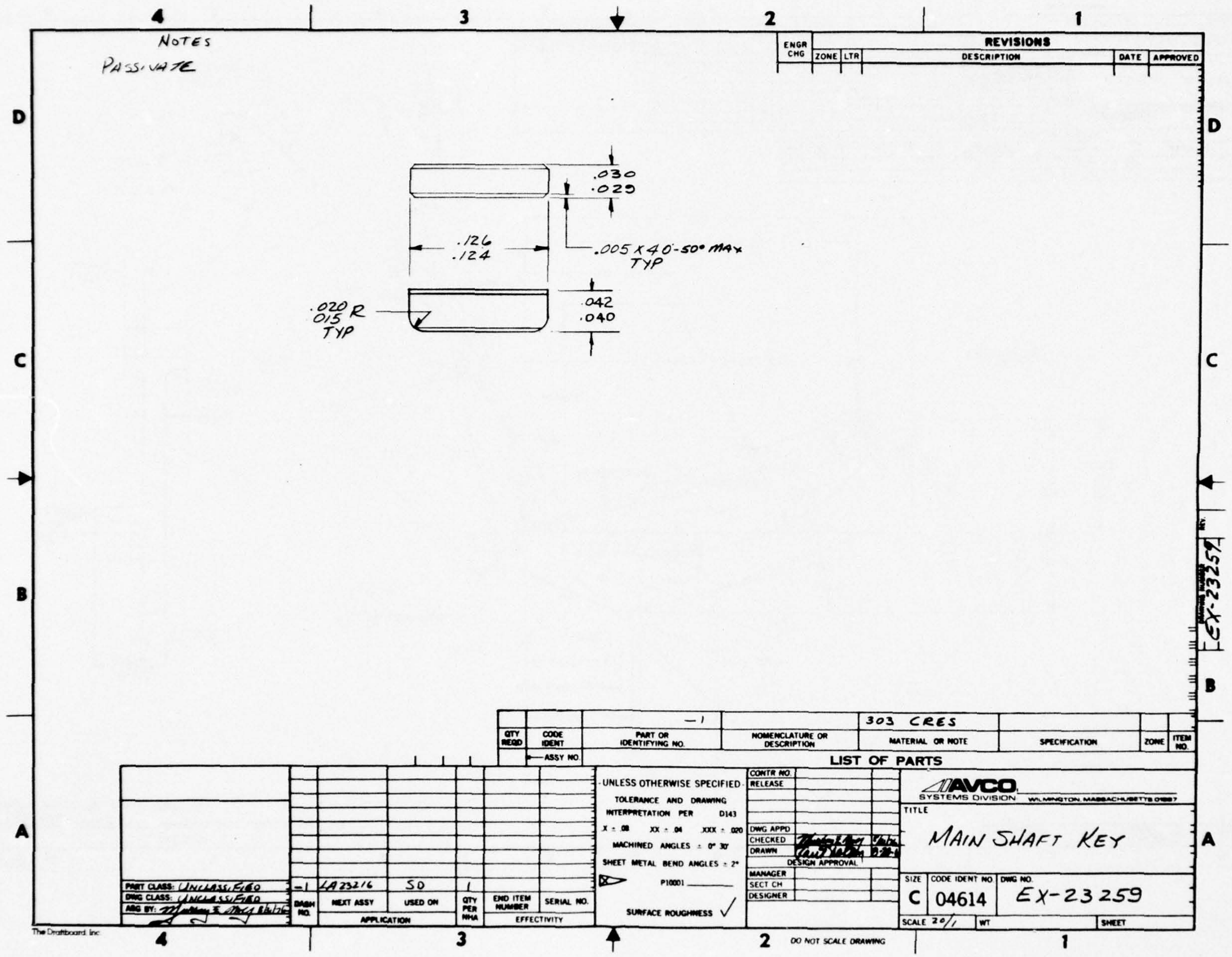


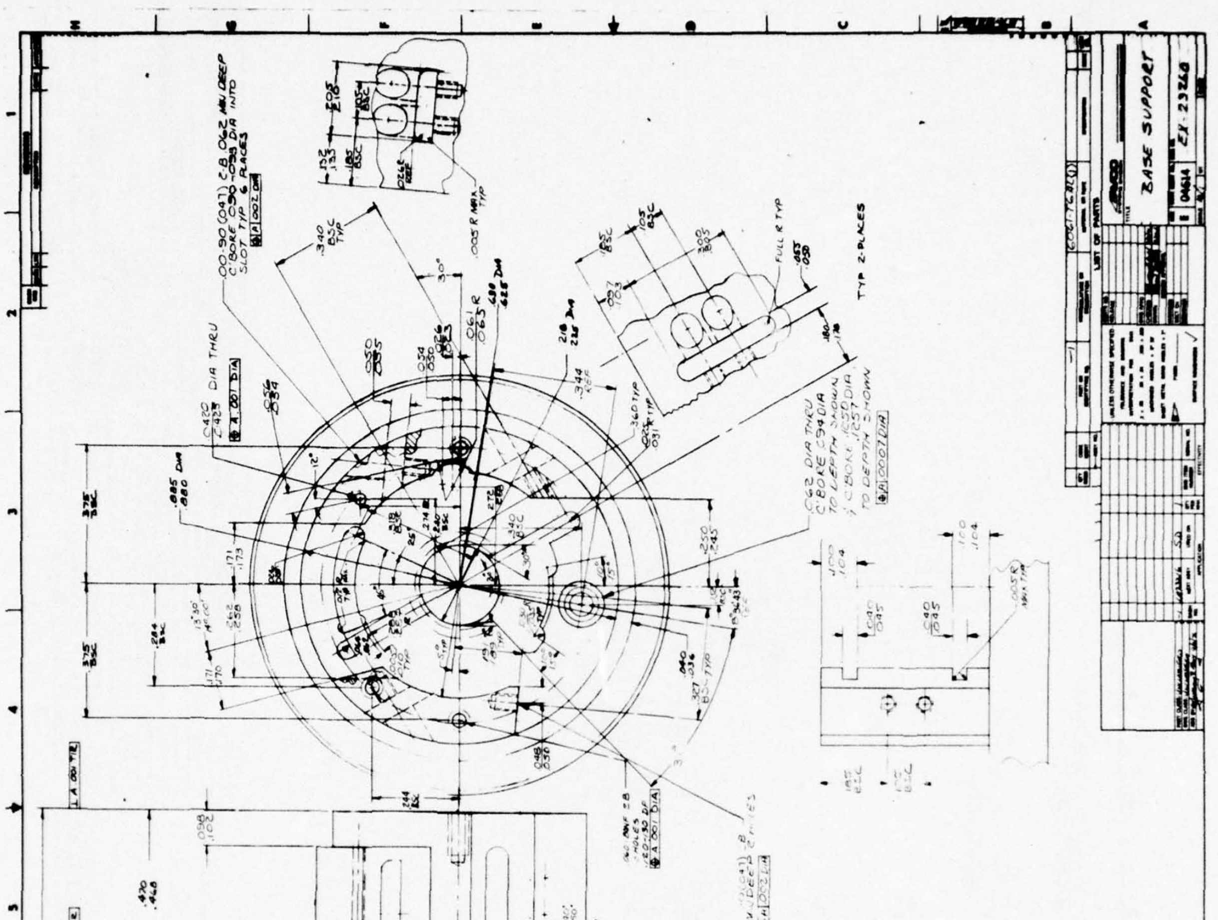
GEAR DATA (REF)
PRESSURE ANGLE 20°
PITCH 56
NO. OF TEETH 56
FACE THICKNESS .187
.800 DIA
.798
A .002 TIR
.050 TYP
21°15' 20°35'
42°15' 41°30'
.005 R MAX TYP
.1253 DIA .1248 (REF)
A
.604 DIA .602 (REF)
.5833 DIA .5823 (REF)
.031 DIA .250 DEEP
.070 .068
.190 R .184
.240 R .238
.054 .052
.005 R MAX
.122 .120
.037 .035
.230 R .225 R
.010 .008
.030 R
.005 R MAX
.030 .025 X 40°-50°
3 PASSIVATE
2 LOCATE CENTERLINE THRU CENTER OF TOOTH
1 MAKE FROM NORDEX CO. NO. LAS-U5-56 Q14 OR EQUIVALENT
NOTE
1 CRES 303 QQ-S-764
LIST OF PARTS
AVCO SYSTEMS DIVISION
DRIVE GEAR
D 04614 EX-23255
SCALE 10/1
EX-23255

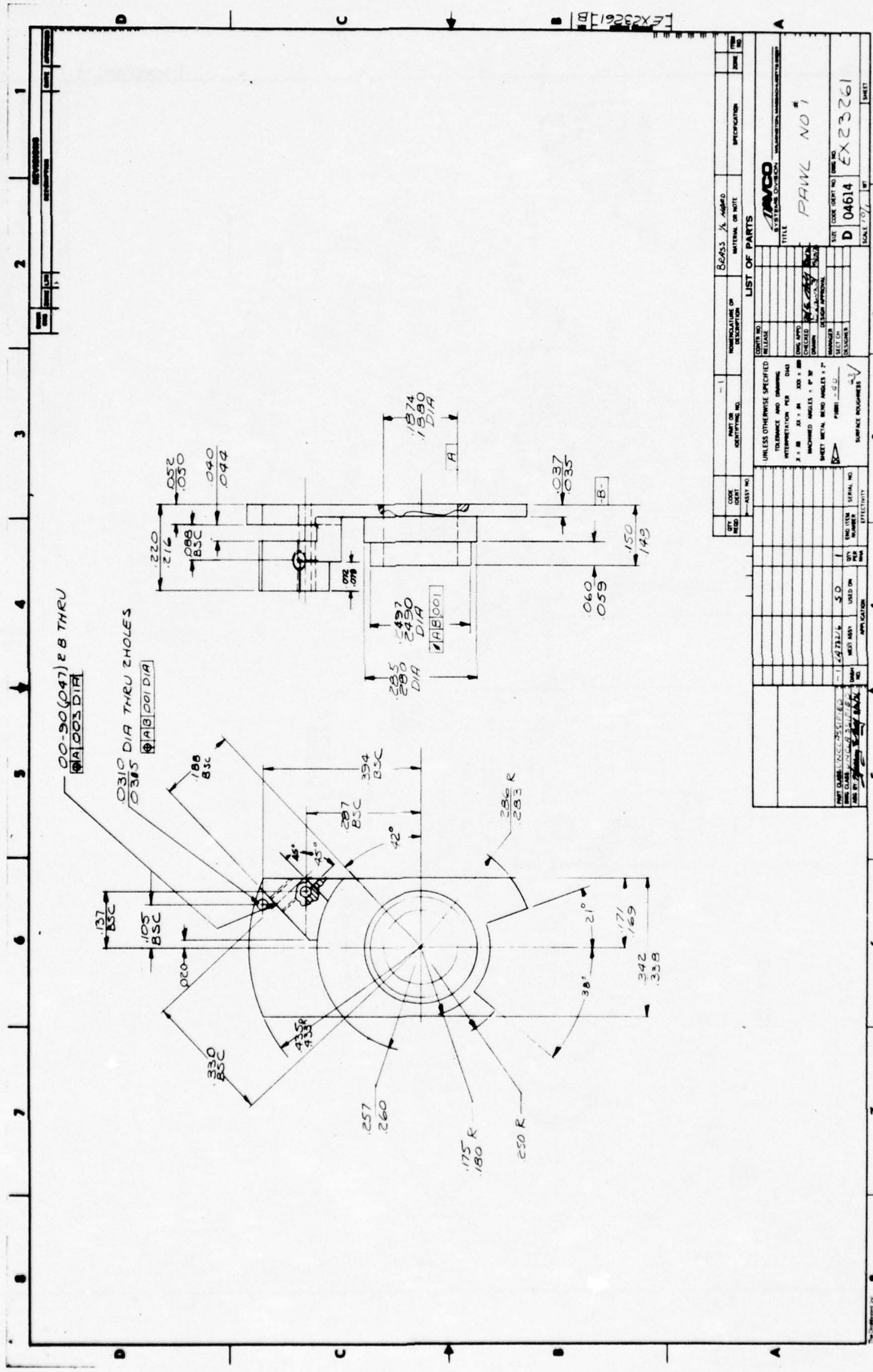

MAIN SHAFT
EX-23256
D 04614
CRES 303
LIST OF PARTS
REVISIONS
SECTION B-B
VIEW A
PLAN VIEW
1 PASSIVATE

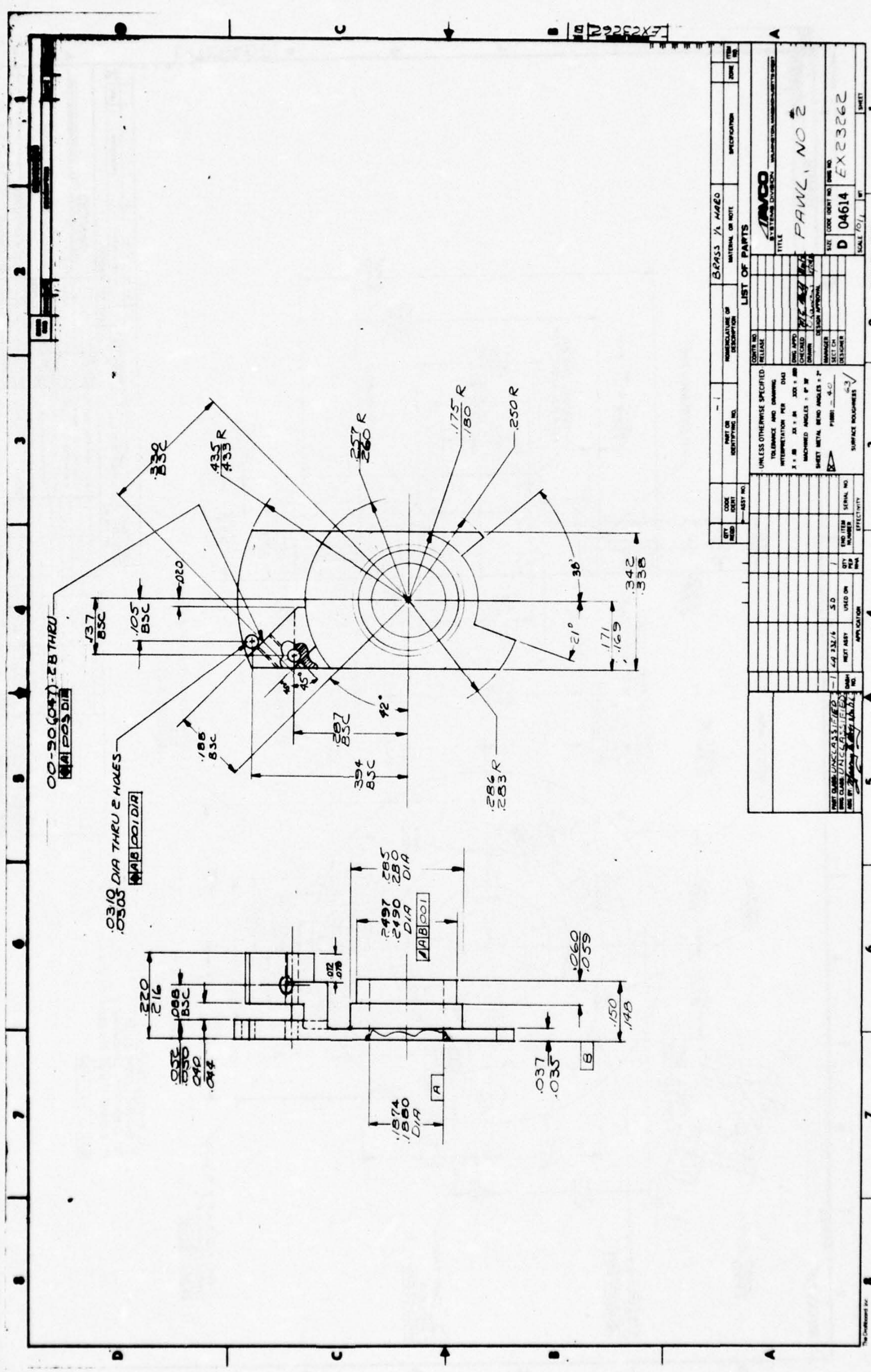

REVISIONS
ENGR CHG
ZONE
LTR
DESCRIPTION
DATE
APPROVED
EX-23257
.090
.088 DIA
.020
.018
.005 R MAX
.090
.088 SP. R
.150
.145
.005 x 40-50° OR R
.030
.029 DIA
BRASS ½ HARD
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR NOTE
SPECIFICATION
ZONE
ITEM NO.
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
MACHINED ANGLES
SHEET METAL BEND ANGLES
SURFACE ROUGHNESS
CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER
AVCO SYSTEMS DIVISION
TITLE
SPRING THRUST PIN
SIZE
CODE IDENT NO
DWG NO.
C
04614
EX-23257
SCALE
WT
SHEET
DO NOT SCALE DRAWING
-1
LA 23216
S.D
DASH NO.
NEXT ASSY
USED ON
APPLICATION
QTY PER NHA
END ITEM NUMBER
SERIAL NO.
EFFECTIVITY
PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED


LOCK ARM
EX23258
AVCO SYSTEMS DIVISION
LIST OF PARTS
D 04614
DETAIL A SCALE 6/1
UNLESS OTHERWISE SPECIFIED

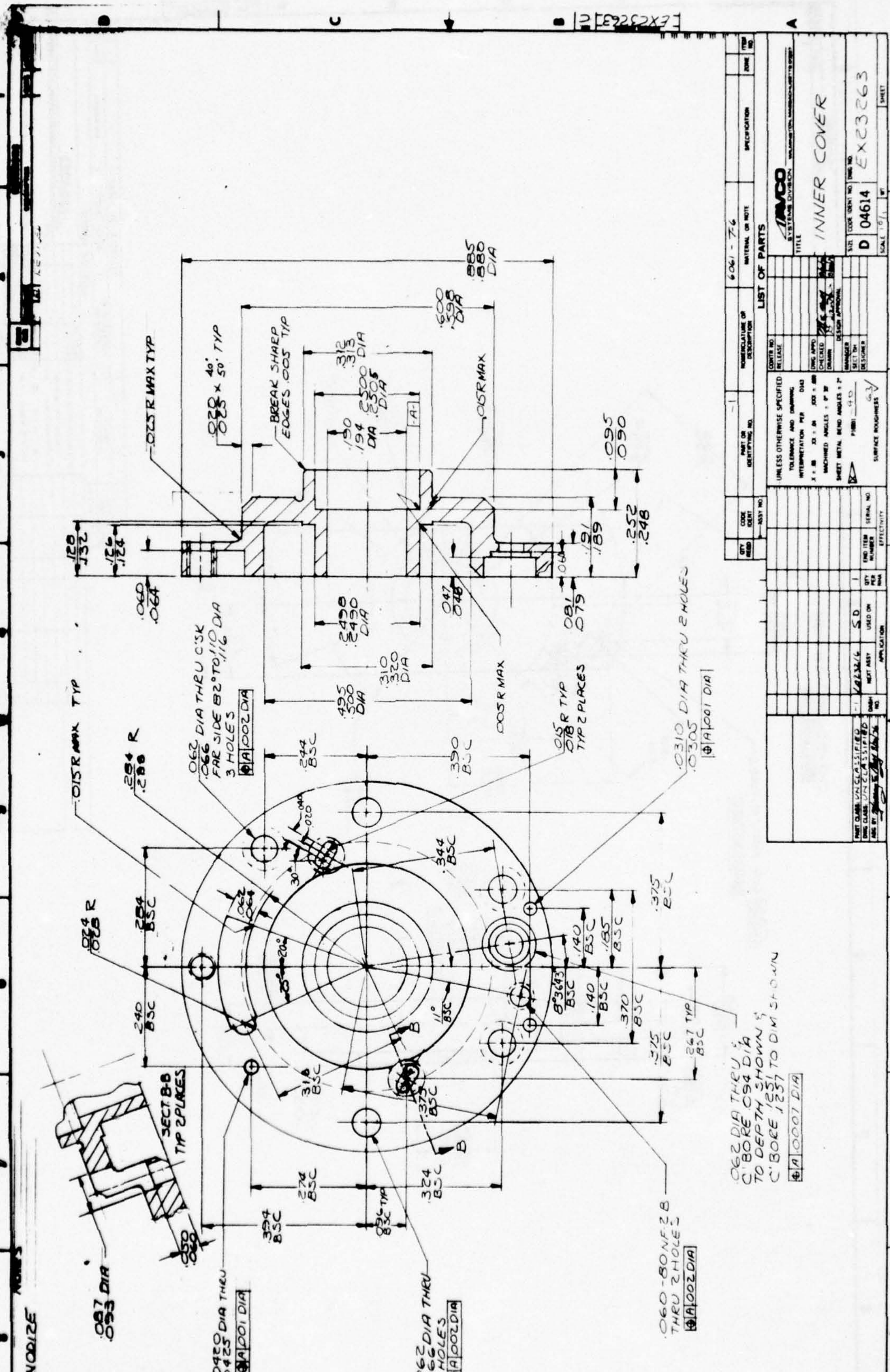

NOTES
PASSIVATE
.030
.029
.126
.124
.005 X 40°-50° MAX
TYP
.020 R
.015
TYP
.042
.040
REVISIONS
ENGR CHG
ZONE
LTR
DESCRIPTION
DATE
APPROVED
EX-23259
—1
303 CRES
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR NOTE
SPECIFICATION
ZONE
ITEM NO.
ASSY NO.
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING
INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001
SURFACE ROUGHNESS
CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER
AVCO
SYSTEMS DIVISION
WILMINGTON, MASSACHUSETTS
TITLE
MAIN SHAFT KEY
SIZE
C
CODE IDENT NO.
04614
DWG NO.
EX-23259
SCALE 20/1
WT
SHEET
PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
—1
LA23216
SD
1
DASH NO.
NEXT ASSY
USED ON
QTY PER NHA
END ITEM NUMBER
SERIAL NO.
APPLICATION
EFFECTIVITY
DO NOT SCALE DRAWING
The Draftboard Inc.


BASE SUPPORT
TYP 2-PLACES
ANODIZE

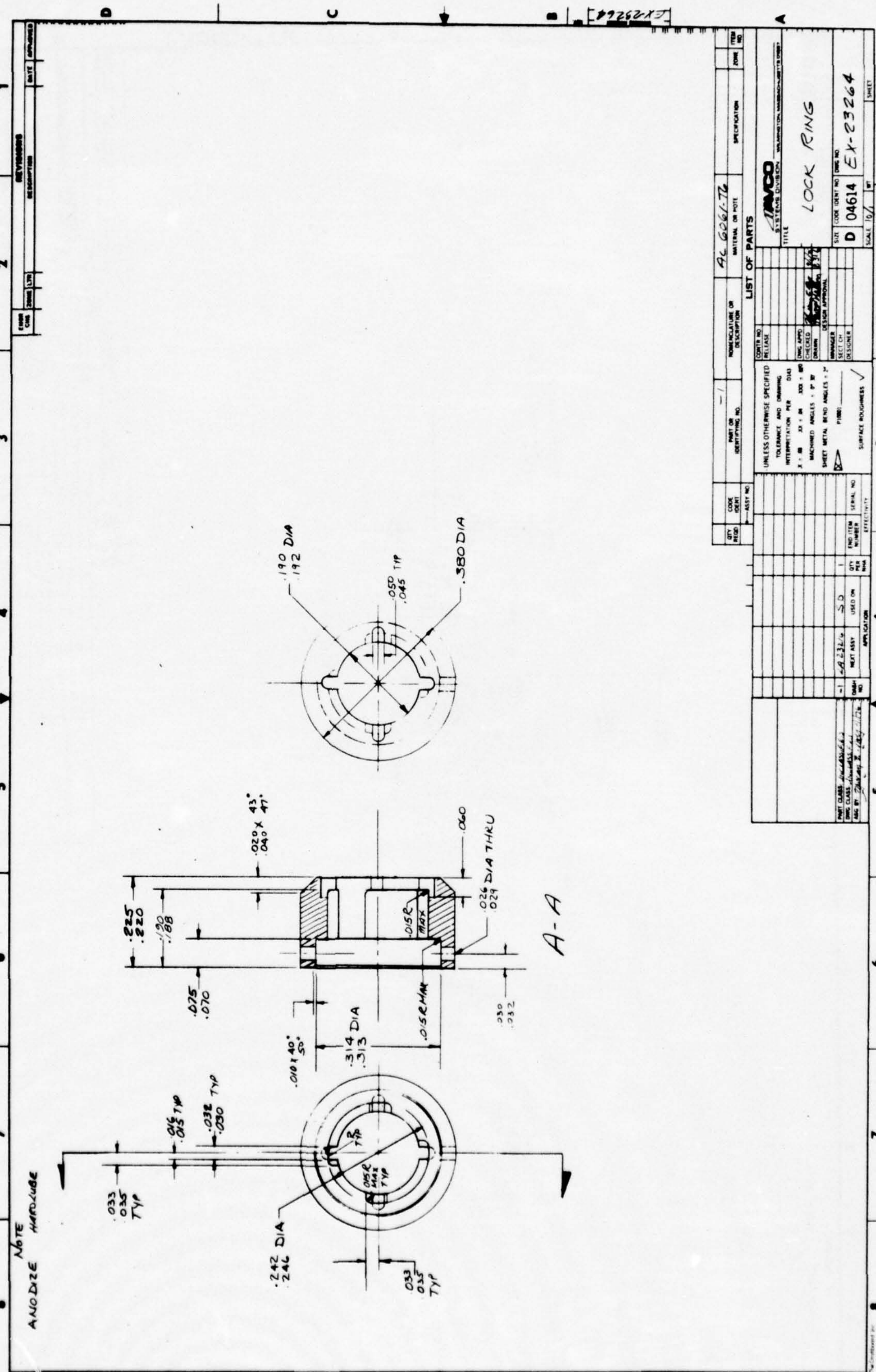

PAWL NO 1
EX23261
AVCO SYSTEMS DIVISION
LIST OF PARTS
BRASS 1/2 HARD
D 04614
UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
00-90(.047) 2 B THRU
.0310 .0385 DIA THRU 2 HOLES

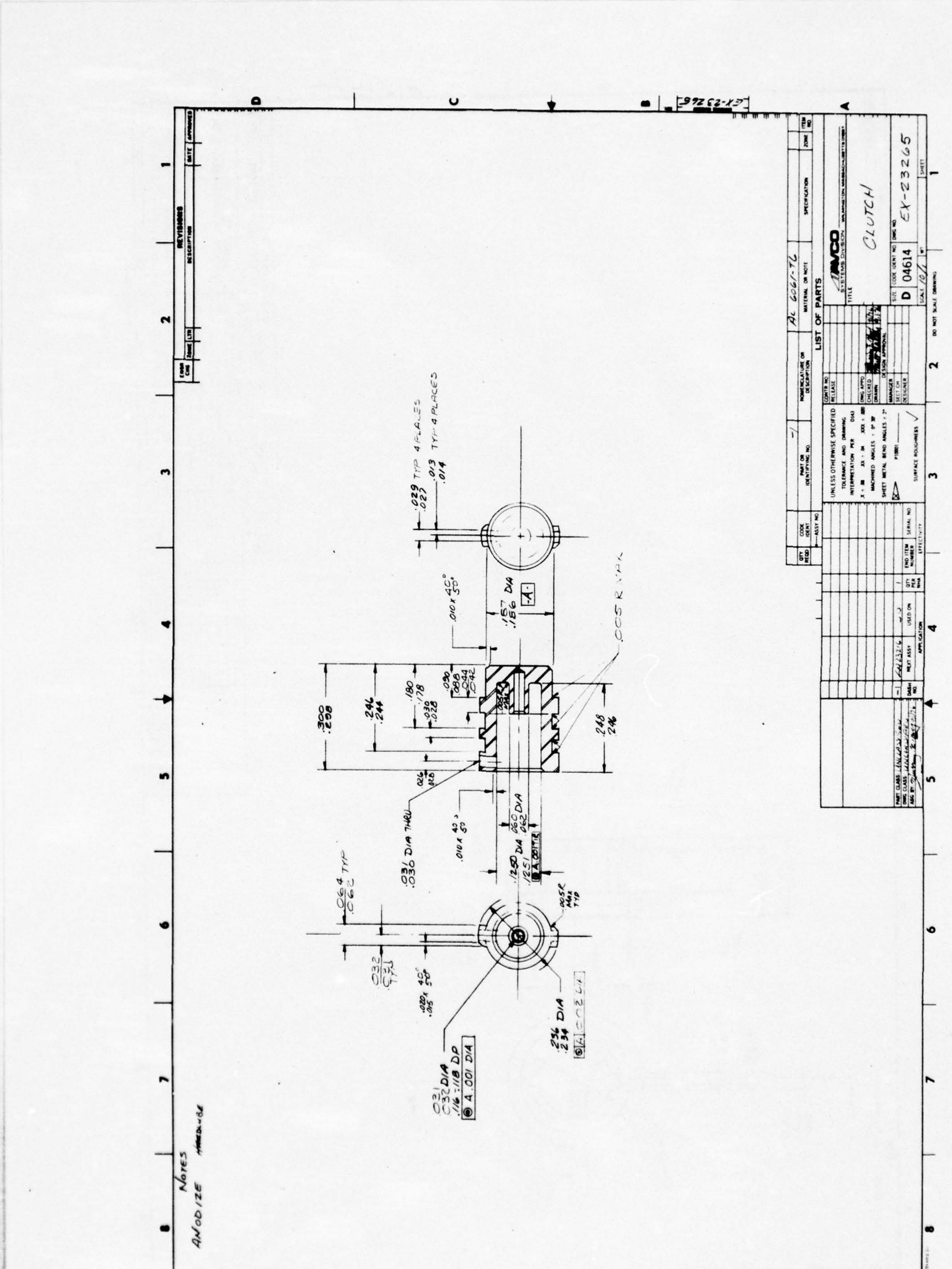


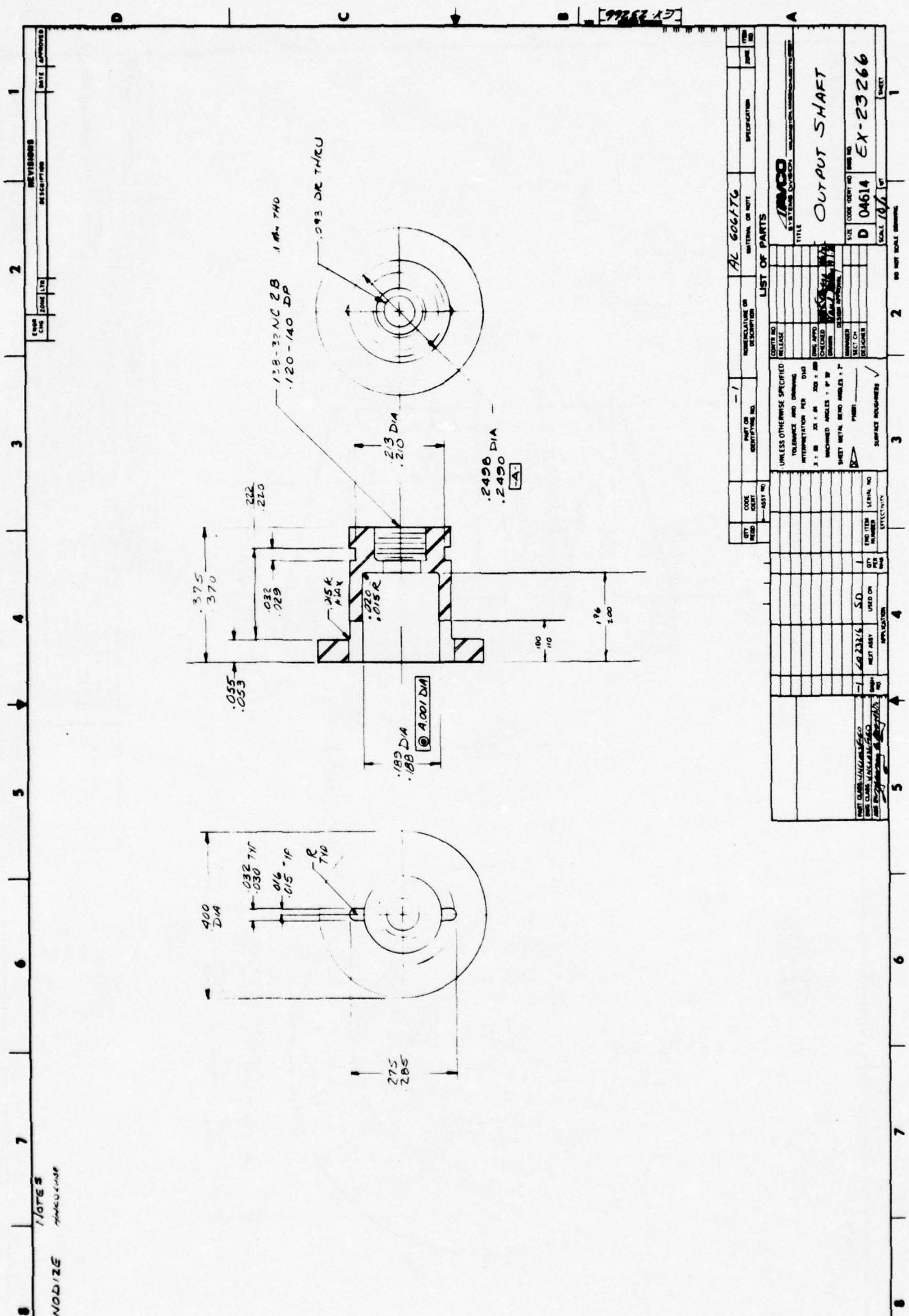
PAWL, NO 2
EX23262
AVCO SYSTEMS DIVISION
LIST OF PARTS
BRASS 1/2 HARD
UNLESS OTHERWISE SPECIFIED
D 04614
UNCLASSIFIED



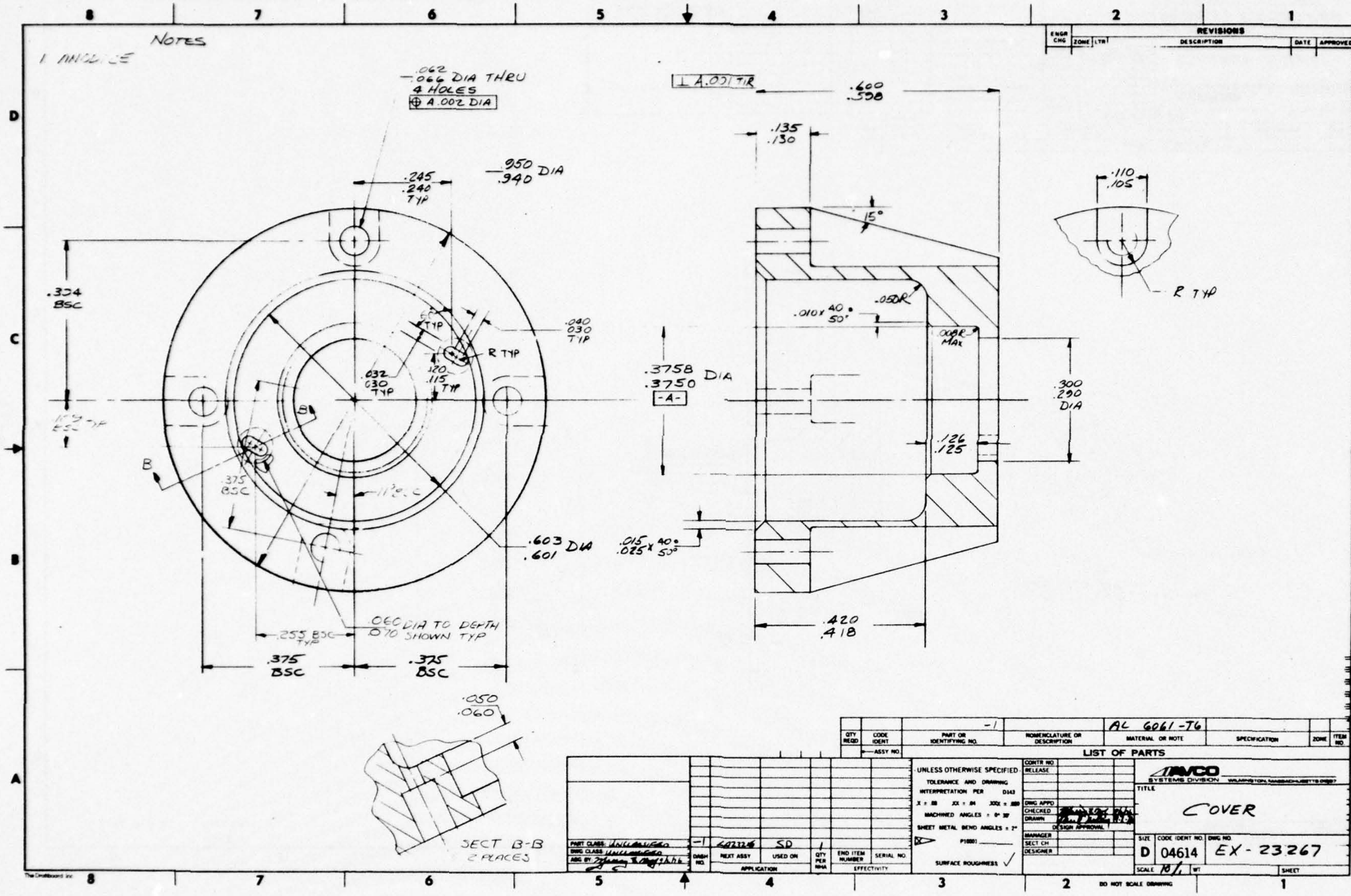
INNER COVER
EX23263
D 04614
AVCO SYSTEMS DIVISION
LIST OF PARTS
6061-T6
UNLESS OTHERWISE SPECIFIED
SECT B-B TYP 2 PLACES
ANODIZE

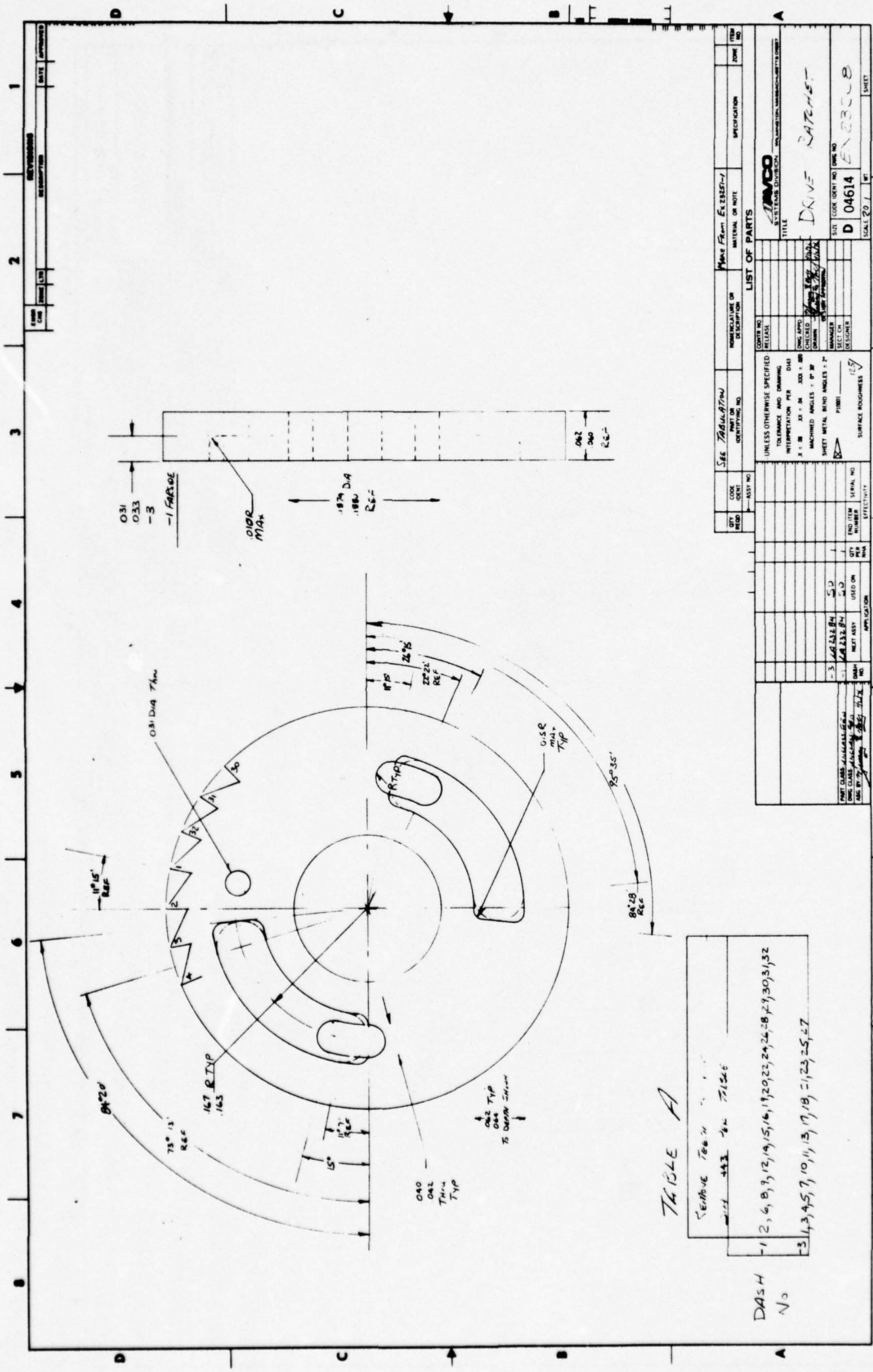

NOTE
ANODIZE HARDLUBE
.033
.035
TYP
.016
.015 TYP
.032
.030 TYP
.242
.246 DIA
.015R
MAX
TYP
.225
.220
.190
.188
.075
.070
.020 X 43°
.040 47°
.010 X 40°
50°
.314
.313 DIA
.015R MAX
.015R
MAX
.060
.026
.029 DIA THRU
.030
.032
A-A
.190
.192 DIA
.050
.045 TYP
.380 DIA
REVISIONS
AL 6061-T6
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
SURFACE ROUGHNESS
AVCO
SYSTEMS DIVISION
LOCK RING
D 04614 EX-23264
DO NOT SCALE DRAWING

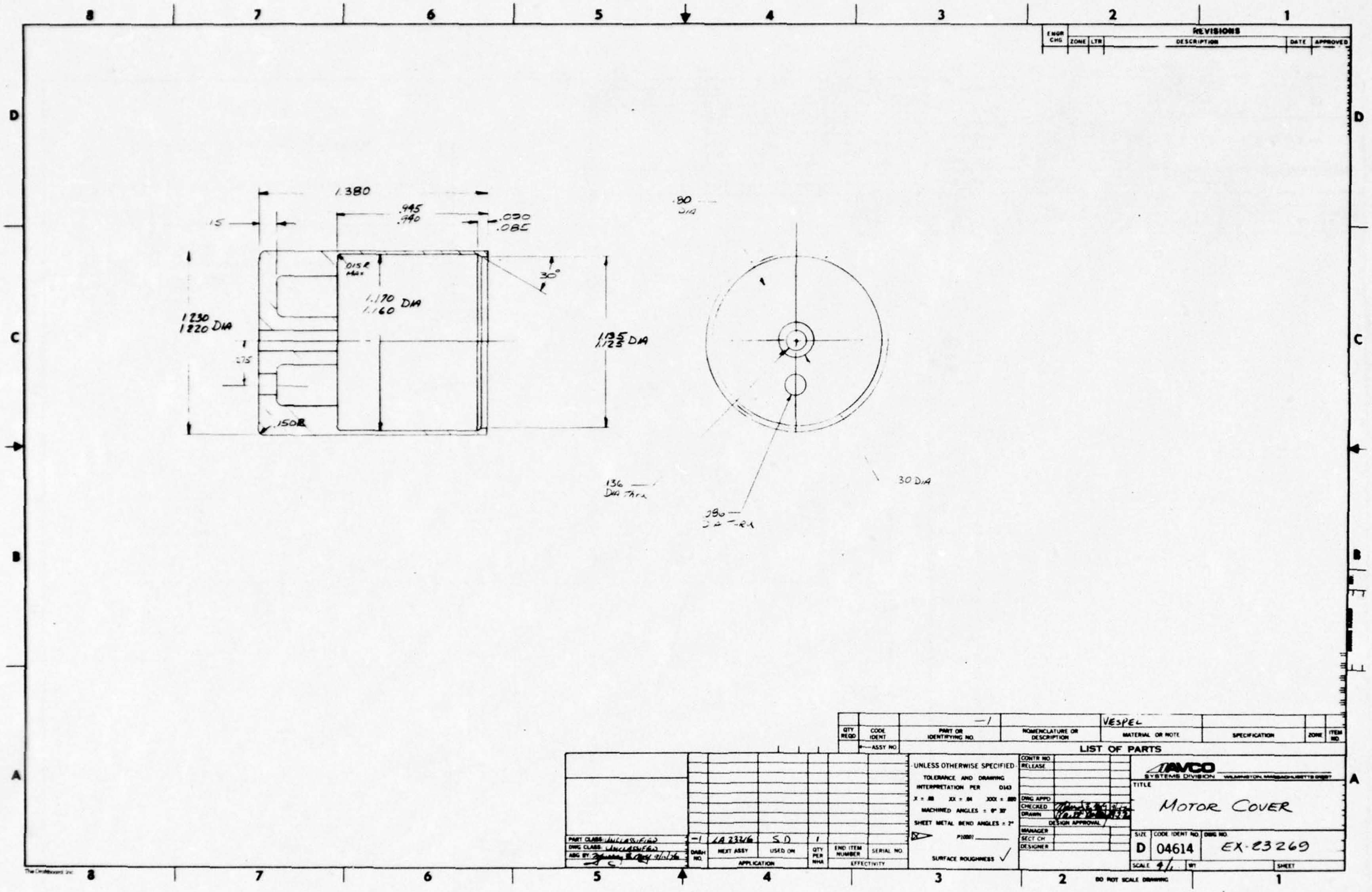

REVISIONS
NOTES
ANODIZE
LIST OF PARTS
AL 6061-T6
UNLESS OTHERWISE SPECIFIED
SURFACE ROUGHNESS
AVCO
SYSTEMS DIVISION
CLUTCH
D 04614
EX-23265
DO NOT SCALE DRAWING
.029 .027 TYP 4 PLACES
.013 .014 TYP 4 PLACES
.157 .156 DIA
.010 x 45° 50°
.005 R MAX
.300 .298
.246 .244
.180 .178
.248 .246
.031 .030 DIA THRU
.1250 .1251 DIA
.060 .062 DIA
.064 .062 TYP
.032 .031 TYP
.236 .234 DIA
.031 .032 DIA .116 .118 DP
A .001 DIA

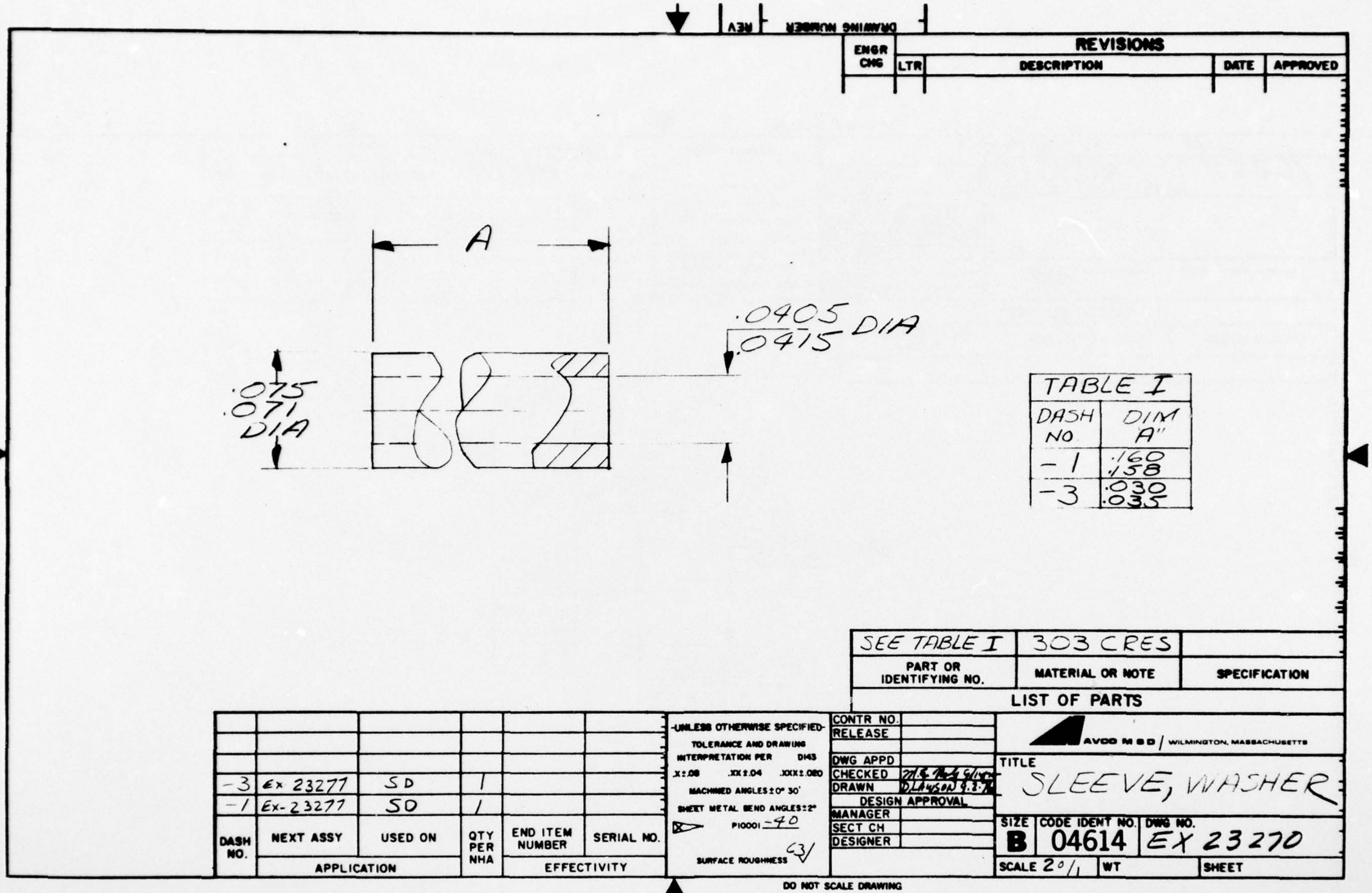


OUTPUT SHAFT
EX-23266
D 04614
AL 6061T6
LIST OF PARTS
REVISIONS
UNLESS OTHERWISE SPECIFIED
NOTES
ANODIZE
.138-32NC 2B
.120-.140 DP
.093 DR THRU
.2498 DIA
.2490
.189 DIA
.188
A .001 DIA
.375
.370
.400 DIA


NOTES
1. ANODIZE
.062
.066 DIA THRU
4 HOLES
⊕ A .002 DIA
.245
.240
TYP
.950
.940 DIA
.324
BSC
.040
.030
TYP
R TYP
.032
.030
TYP
.120
.115 TYP
.3758
.3750 DIA
-A-
.375
BSC
.603
.601 DIA
.015 X 40°
.025 X 50°
.060 DIA TO DEPTH
.070 SHOWN TYP
.255 BSC
TYP
.375
BSC
.375
BSC
⊥ A .001 TIR
.600
.598
.135
.130
15°
.010 X 40°
50°
.050R
.008R
MAX
.300
.290
DIA
.126
.125
.420
.418
.110
.105
R TYP
.050
.060
SECT B-B
2 PLACES
REVISIONS
ENGR CHG
ZONE
LTR
DESCRIPTION
DATE
APPROVED
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO.
-1
NOMENCLATURE OR DESCRIPTION
AL 6061-T6
MATERIAL OR NOTE
SPECIFICATION
ZONE
ITEM NO.
ASSY NO
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING
INTERPRETATION PER D143
MACHINED ANGLES
SHEET METAL BEND ANGLES
SURFACE ROUGHNESS
CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER
AVCO
SYSTEMS DIVISION
TITLE
COVER
SIZE
CODE IDENT NO.
DWG NO.
D
04614
EX-23267
SCALE
WT
SHEET
DO NOT SCALE DRAWING
PART CLASS
DWG CLASS
DASH NO.
NEXT ASSY
USED ON
SD
APPLICATION
QTY PER
END ITEM NUMBER
SERIAL NO.
EFFECTIVITY
EX-23267


AVCO
SYSTEMS DIVISION
DRIVE RATCHET
D 04614
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
SURFACE ROUGHNESS
DO NOT SCALE DRAWING
TABLE A
DASH No

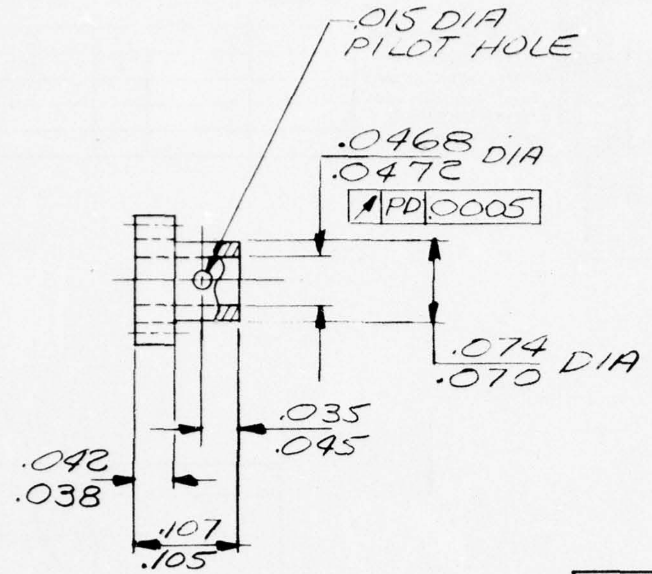

REVISIONS
ENGR CHG
ZONE
LTR
DESCRIPTION
DATE
APPROVED
1.380
.15
.945
.940
.090
.085
.015 R MAX
30°
1.170 DIA
1.160
1.230
1.220 DIA
.275
1.135
1.125 DIA
.150 R
.80 DIA
.136 DIA THRU
.080 DIA THRU
.30 DIA
-1
VESPEL
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR NOTE
SPECIFICATION
ZONE
ITEM NO
ASSY NO
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
SURFACE ROUGHNESS
CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER
AVCO
SYSTEMS DIVISION
TITLE
MOTOR COVER
SIZE
CODE IDENT NO
DWG NO
D
04614
EX-23269
SCALE 4/1
WT
SHEET
DO NOT SCALE DRAWING
PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
-1
LA 23216
SD
1
DASH NO.
NEXT ASSY
USED ON
QTY PER NHA
END ITEM NUMBER
SERIAL NO.
APPLICATION
EFFECTIVITY



REV
DRAWING NUMBER
REVISIONS
ENGR CHG
LTR
DESCRIPTION
DATE
APPROVED
A
.0405
.0415 DIA
.075
.071
DIA
TABLE I
DASH NO.
DIM "A"
-1
.160
.158
-3
.030
.035
SEE TABLE I
303 CRES
PART OR IDENTIFYING NO.
MATERIAL OR NOTE
SPECIFICATION
LIST OF PARTS
-3
Ex 23277
SD
1
-1
Ex-23277
SD
1
DASH NO.
NEXT ASSY
USED ON
QTY PER NHA
END ITEM NUMBER
SERIAL NO.
APPLICATION
EFFECTIVITY
-UNLESS OTHERWISE SPECIFIED-
TOLERANCE AND DRAWING
INTERPRETATION PER D143
.X±.08 .XX±.04 .XXX±.080
MACHINED ANGLES ±0° 30'
SHEET METAL BEND ANGLES ±2°
P10001 -40
SURFACE ROUGHNESS 63
DO NOT SCALE DRAWING
CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DLAWSON 9.3.76
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER
AVCO M S D / WILMINGTON, MASSACHUSETTS
TITLE
SLEEVE, WASHER
SIZE
B
CODE IDENT NO.
04614
DWG NO.
EX 23270
SCALE 20/1
WT
SHEET

NOTES

1. MAKE FROM F5-2 PINION PURCHASE FROM: PIC FED CODE NO. 00141
416 SS HT TO 140,000 PSI 11/IN



ENGR CHG	REVISIONS			
	LTR	DESCRIPTION	DATE	APPROVED

DRAWING NUMBER | REV

PART OR IDENTIFYING NO.	MATERIAL OR NOTE	SPECIFICATION
-1	1	

LIST OF PARTS

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	EX23275	SD	1		

APPLICATION | EFFECTIVITY

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
.X ±.08 .XX ±.04 .XXX ±.020
MACHINED ANGLES ±0° 30'
SHEET METAL BEND ANGLES ±2°
P10001 -40
SURFACE ROUGHNESS 32

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN DIAGON 7-2-
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO M S D / WILMINGTON, MASSACHUSETTS

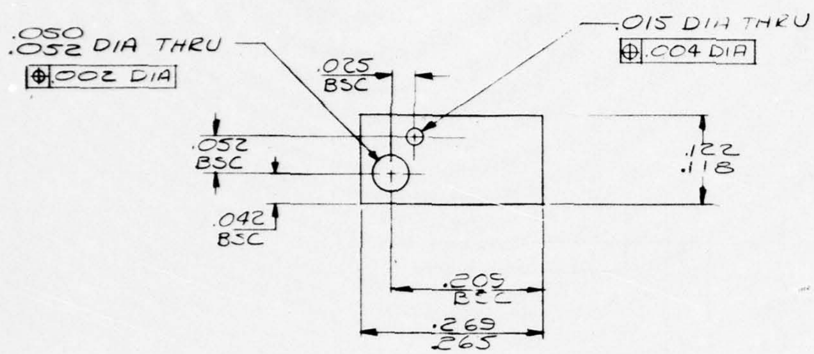
TITLE GEAR

SIZE	CODE IDENT NO.	DWG NO.
B	04614	EX 23271

SCALE 10/1 | WT | SHEET

DO NOT SCALE DRAWING

NOTES



REVISIONS

ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

LIST OF PARTS

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
		-1		.004 THK BERYLCO NICKEL 440 ½ HT			

ASSY NO

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 - 40
SURFACE ROUGHNESS 63

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN D. Lawson
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE DRIVE PAWL

SIZE C | CODE IDENT NO 04614 | DWG NO. EX23272

SCALE 10/1 | WT | SHEET

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	LA 23216	SD	2		

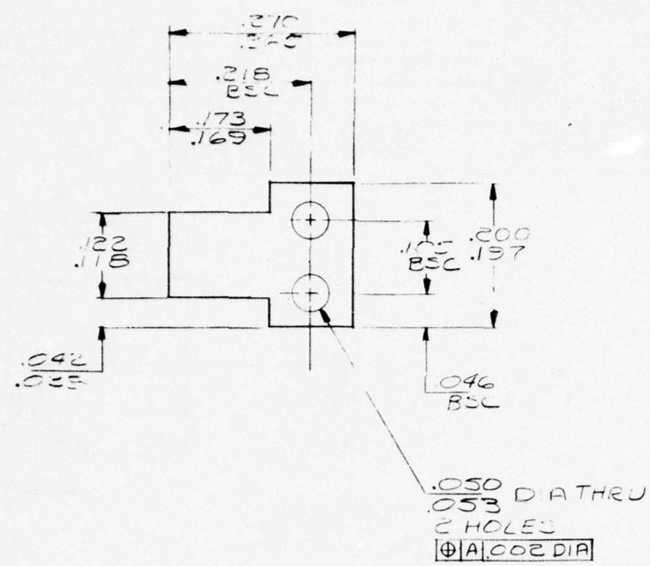
APPLICATION — EFFECTIVITY

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ASG BY:

DO NOT SCALE DRAWING

The Draftboard Inc

NOTE:



ENGR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
		-1		.004 THK BERYLCO NICKEL 440 ½ HT			

LIST OF PARTS

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	LA 2346	3D	2		

APPLICATION — EFFECTIVITY

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ABG BY: 9/16/76

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 -40
SURFACE ROUGHNESS 63√

CONTR NO.
RELEASE
DWG APPD
CHECKED 9/1/76
DRAWN D. Dawson 8/23/76
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE FULL PAWL

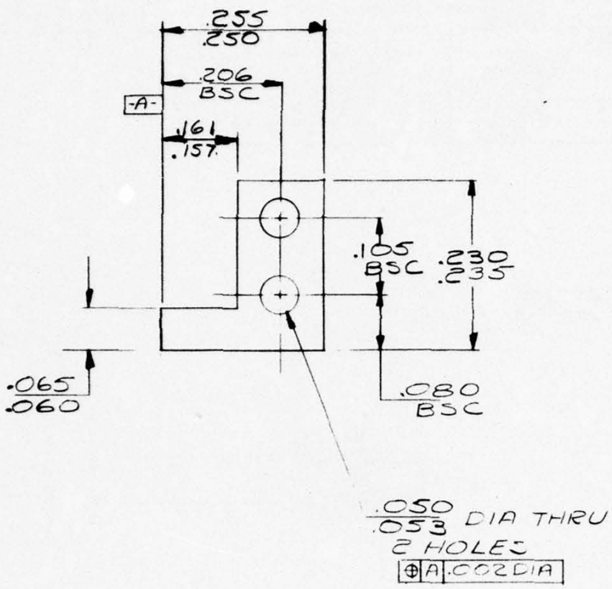
SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX 23273

SCALE 10/1 WT SHEET

DO NOT SCALE DRAWING

The Draftboard Inc

NOTES



ENGR CHG	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

LIST OF PARTS

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		.004 THK BERYLCO NICKEL 440 ½ H.T.			

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	LA 2326	SD	2		
	APPLICATION			EFFECTIVITY	

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ASG BY: [signature] 9/16/76

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 .XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 = 40
SURFACE ROUGHNESS 63√

CONTR NO.
RELEASE
DWG APPD
CHECKED [signature] 9/16/76
DRAWN D. LAWSON 9/2/76
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE HALF PAWL

SIZE C | CODE IDENT NO 04614 | DWG NO. EX33274

SCALE 15/1 | WT | SHEET

DO NOT SCALE DRAWING

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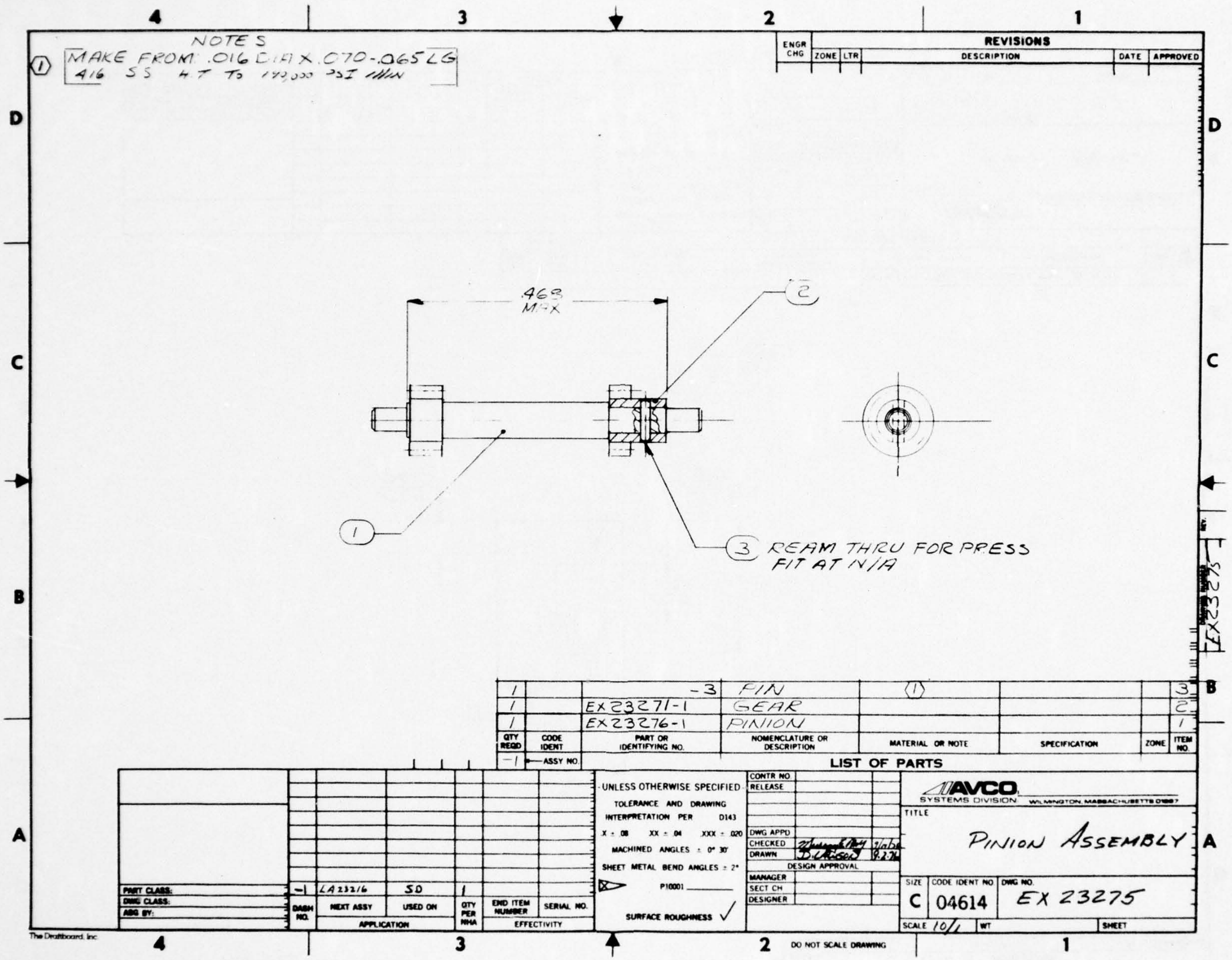
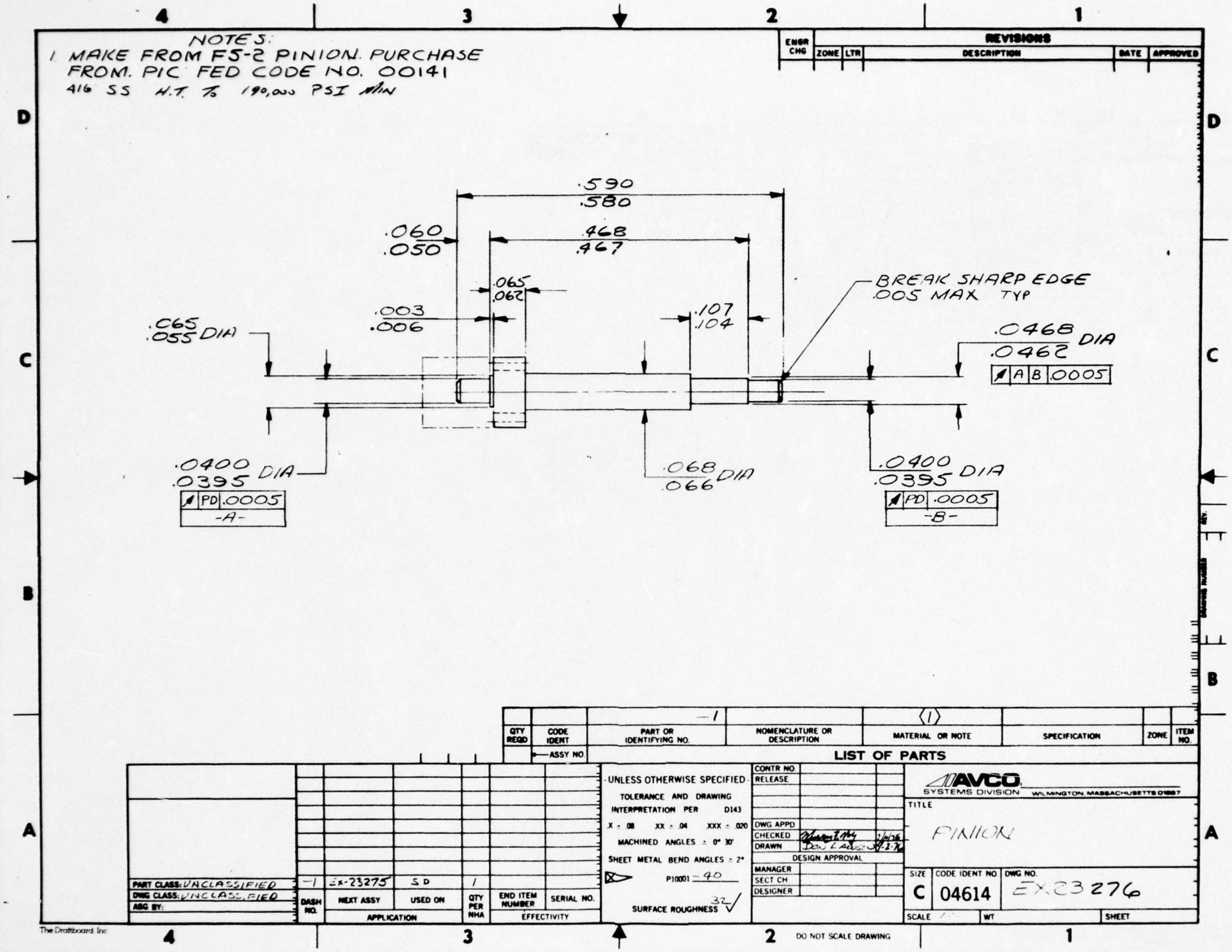
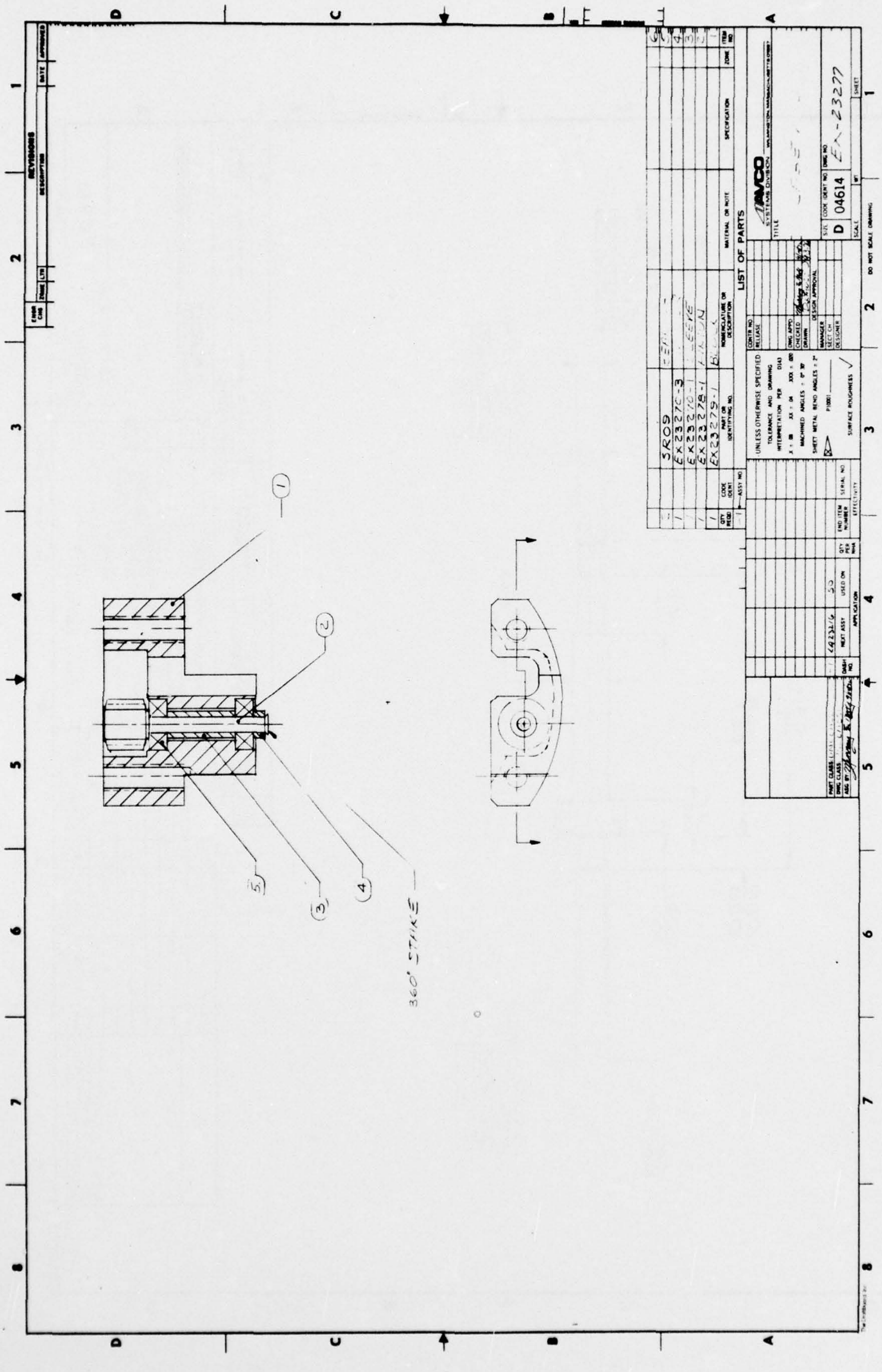

NOTES
1 MAKE FROM .016 DIA X .070-.065 LG
416 SS H.T TO 1?3,000 PSI MIN
.468
MAX
1
2
3 REAM THRU FOR PRESS
FIT AT N/A
REVISIONS
ENGR CHG
ZONE
LTR
DESCRIPTION
DATE
APPROVED
EX23275
1
-3
PIN
1
3
1
EX23271-1
GEAR
2
1
EX23276-1
PINION
1
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR NOTE
SPECIFICATION
ZONE
ITEM NO.
-1
ASSY NO.
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING
INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001
SURFACE ROUGHNESS
CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER
AVCO
SYSTEMS DIVISION
WILMINGTON, MASSACHUSETTS 01887
TITLE
PINION ASSEMBLY
SIZE
C
CODE IDENT NO.
04614
DWG NO.
EX 23275
SCALE 10/1
WT
SHEET
PART CLASS:
DWG CLASS:
ASG BY:
-1
LA23216
SD
1
DASH NO.
NEXT ASSY
USED ON
APPLICATION
QTY PER NHA
END ITEM NUMBER
SERIAL NO.
EFFECTIVITY
DO NOT SCALE DRAWING
The Draftboard, Inc.


NOTES:
1. MAKE FROM FS-2 PINION. PURCHASE FROM. PIC FED CODE NO. 00141
416 SS H.T. To 190,000 PSI MIN
.590
.580
.468
.467
.060
.050
.065
.062
.003
.006
.107
.104
BREAK SHARP EDGE .005 MAX TYP
.065
.055 DIA
.0468
.0462 DIA
A B .0005
.0400
.0395 DIA
PD .0005
-A-
.068
.066 DIA
.0400
.0395 DIA
PD .0005
-B-
REVISIONS
ENGR CHG
ZONE
LTR
DESCRIPTION
DATE
APPROVED
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO.
-1
NOMENCLATURE OR DESCRIPTION
MATERIAL OR NOTE
SPECIFICATION
ZONE
ITEM NO.
ASSY NO
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 = 40
SURFACE ROUGHNESS 32
CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER
AVCO
SYSTEMS DIVISION
WILMINGTON, MASSACHUSETTS 01887
TITLE
PINION
SIZE
C
CODE IDENT NO
04614
DWG NO.
EX23276
SCALE
WT
SHEET
PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ASG BY:
-1
EX-23275
SD
1
DASH NO.
NEXT ASSY
USED ON
QTY PER NHA
END ITEM NUMBER
SERIAL NO.
APPLICATION
EFFECTIVITY
DO NOT SCALE DRAWING
The Draftboard Inc

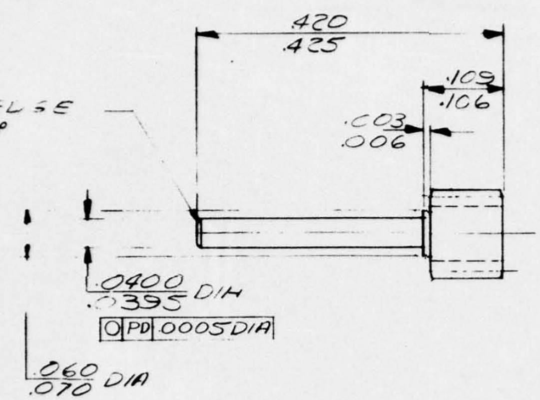

REVISIONS
LIST OF PARTS
SR09
EX23270-3
EX23210-1
EX23278-1
EX23279-1
SLEEVE
UNLESS OTHERWISE SPECIFIED
AVCO
SYSTEMS DIVISION
D
04614
EX-23277
DO NOT SCALE DRAWING
360° STAKE
1
2
3
4
5

NOTES
1. MAKE FROM FS-2 PINION. PURCHASE FROM PIC FED CODE NO. 00141
416 SS HT To 190,000 PSI MIN

REVISIONS

ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

BREAK SHARP ELSE .005 MAX TYP



LIST OF PARTS

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
	ASSY NO.	-1		(1)			

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 = 40
SURFACE ROUGHNESS 63√

PART CLASS. UNCLASSIFIED
DWG CLASS. UNCLASSIFIED

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	EX-23277	SD	1		
	APPLICATION			EFFECTIVITY	

CONTR NO.
RELEASE
DWG APPD
CHECKED
DRAWN D. Dawson
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

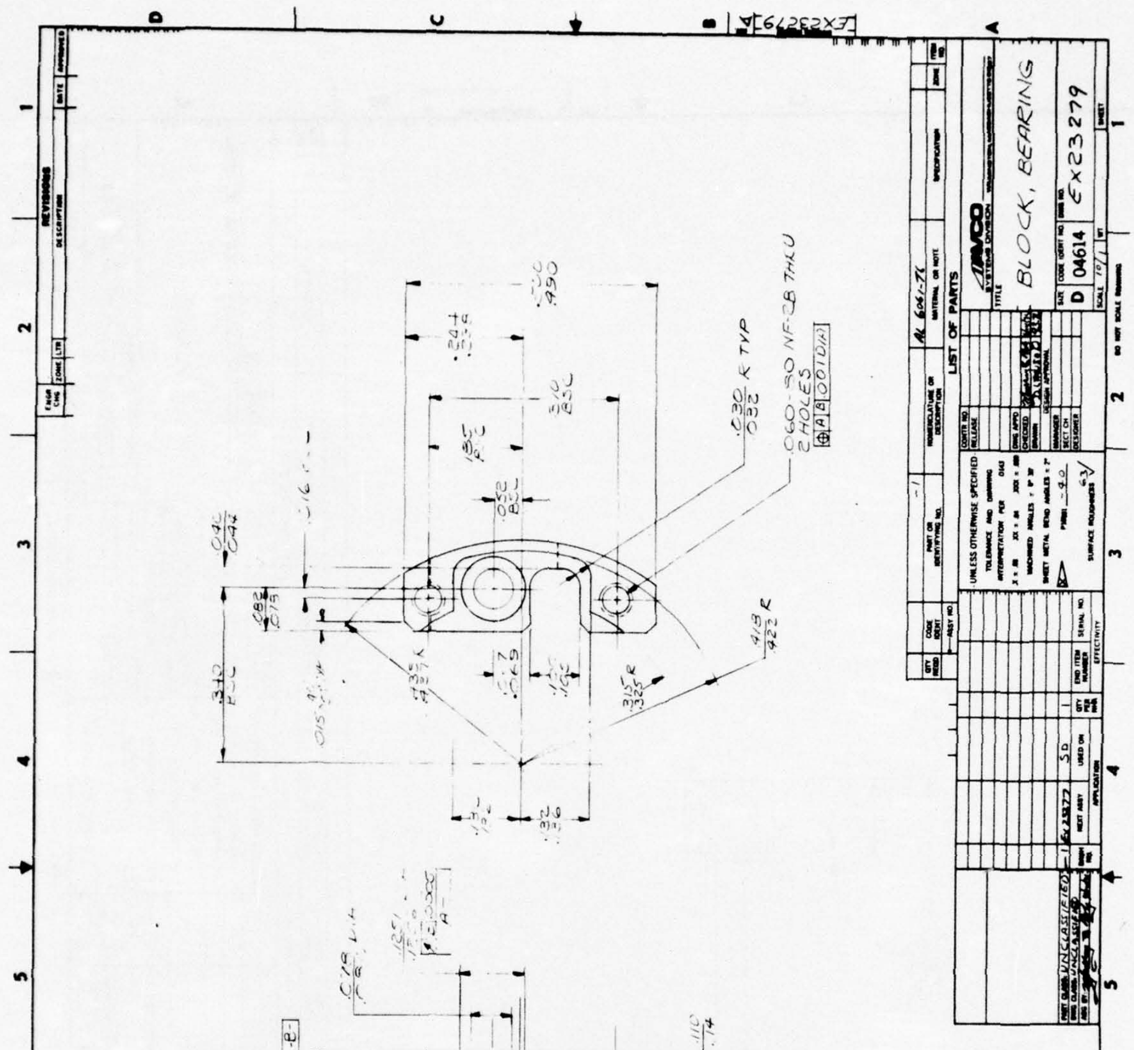
TITLE PINION

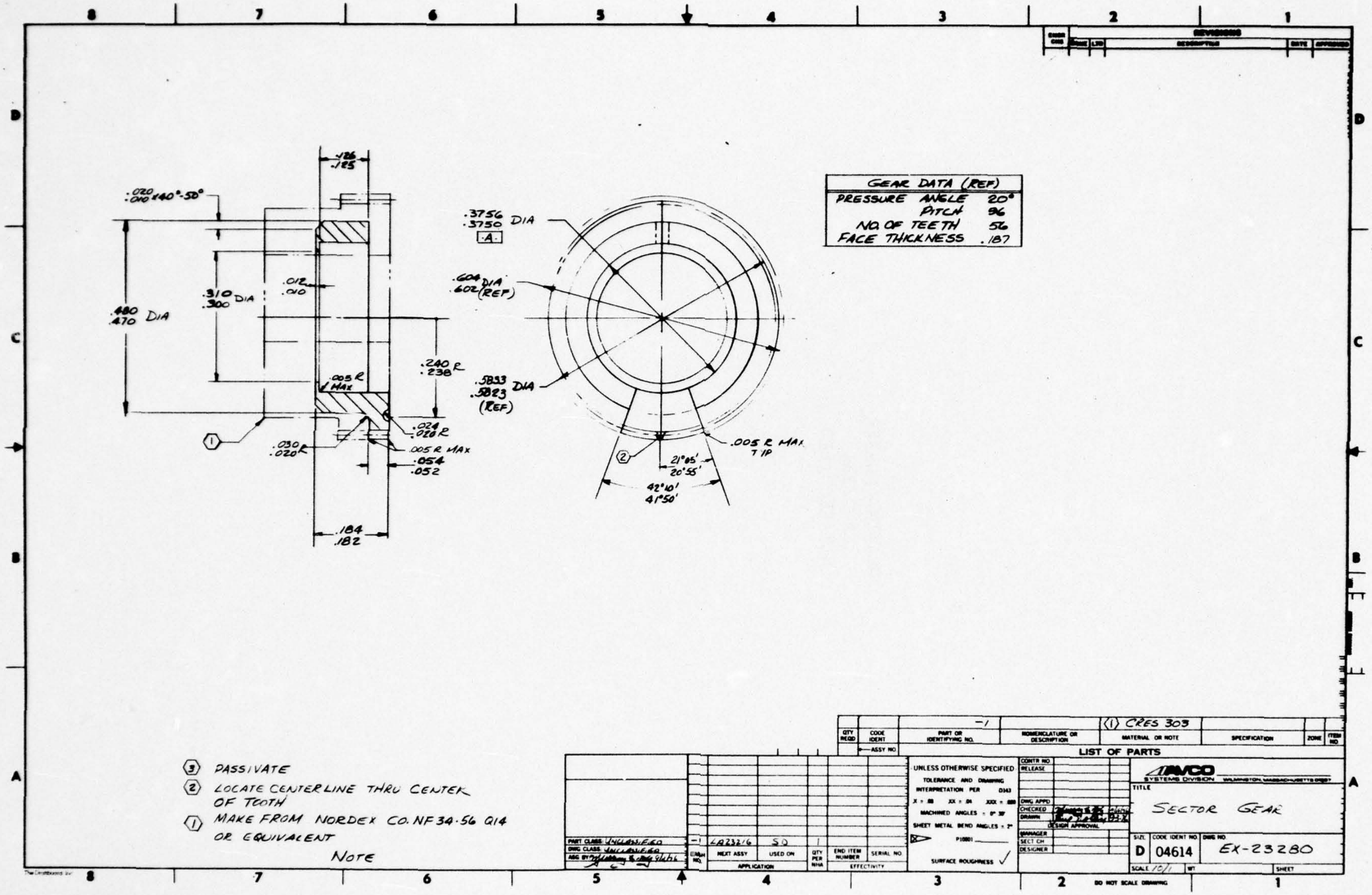
SIZE	CODE IDENT NO.	DWG NO.
C	04614	EX23278

SCALE 10/1 WT SHEET

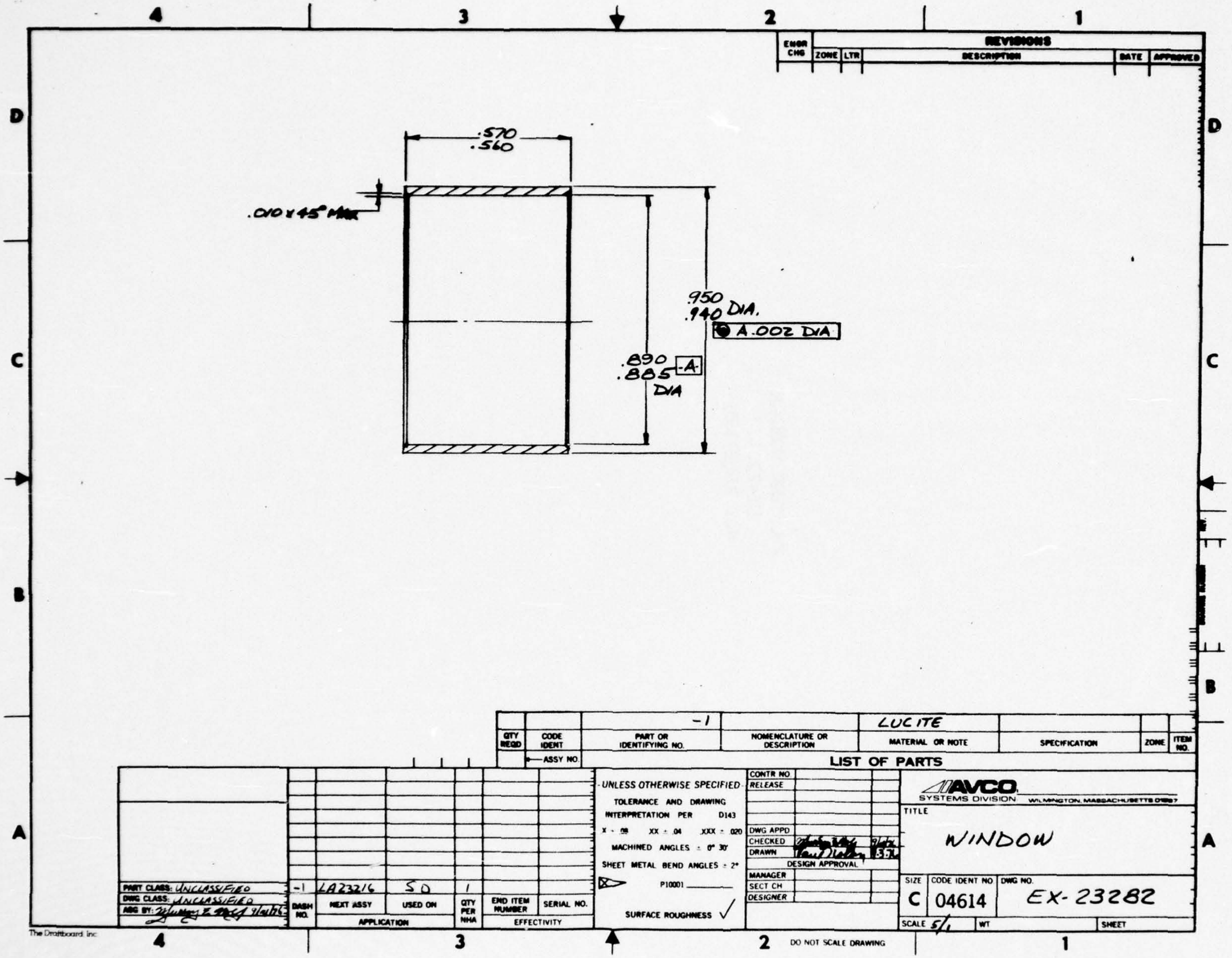
DO NOT SCALE DRAWING

The Draftboard Inc

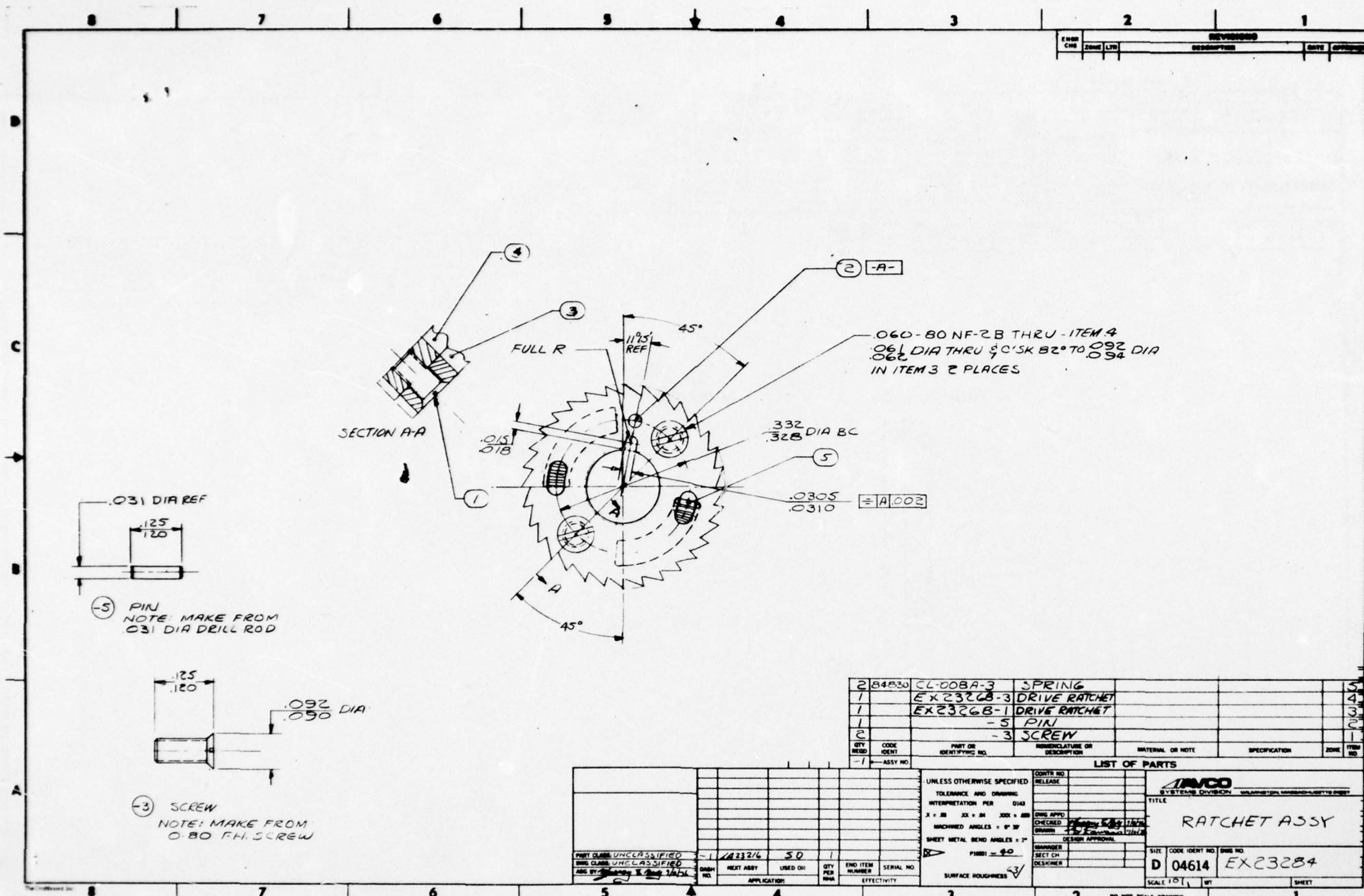

BLOCK, BEARING
EX23279
D 04614
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
SURFACE ROUGHNESS
DO NOT SCALE DRAWING
REVISIONS


GEAR DATA (REF)
PRESSURE ANGLE 20°
PITCH 96
NO. OF TEETH 56
FACE THICKNESS .187
.3756 .3750 DIA
A
.604 .602 DIA (REF)
.5833 .5823 DIA (REF)
.005 R MAX TIP
21°05' 20°55'
42°10' 41°50'
.020 .010 x 40°-50°
.126 .125
.480 .470 DIA
.310 .300 DIA
.012 .010
.240 .238 R
.005 R MAX
.024 .020 R
.005 R MAX
.030 .020 R
.054 .052
.184 .182
3 PASSIVATE
2 LOCATE CENTERLINE THRU CENTER OF TOOTH
1 MAKE FROM NORDEX CO. NF34-56 Q14 OR EQUIVALENT
NOTE
REVISIONS
LIST OF PARTS
-1
1 CRES 303
UNLESS OTHERWISE SPECIFIED
AVCO SYSTEMS DIVISION
TITLE
SECTOR GEAR
D 04614 EX-23280
SCALE 10/1
DO NOT SCALE DRAWING
-1 LA23216 SD 1
NEXT ASSY USED ON
APPLICATION
PART CLASS UNCLASSIFIED
DWG CLASS UNCLASSIFIED

DRAWING NUMBER
EX-23281
NOT REQUIRED

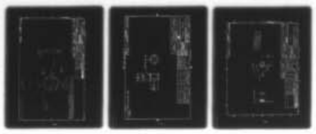

REVISIONS
ENGR CHG
ZONE
LTR
DESCRIPTION
DATE
APPROVED
.570
.560
.010 x 45° MAX
.950
.940 DIA.
A .002 DIA
.890
.885 DIA
-A-
-1
LUCITE
QTY REQD
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR NOTE
SPECIFICATION
ZONE
ITEM NO.
ASSY NO.
LIST OF PARTS
UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001
SURFACE ROUGHNESS
CONTR NO
RELEASE
DWG APPD
CHECKED
DRAWN
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER
AVCO
SYSTEMS DIVISION
WILMINGTON, MASSACHUSETTS 01887
TITLE
WINDOW
SIZE
C
CODE IDENT NO.
04614
DWG NO.
EX-23282
SCALE 5/1
WT
SHEET
PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
-1
LA23216
SD
1
DASH NO.
NEXT ASSY
USED ON
APPLICATION
QTY PER NHA
END ITEM NUMBER
SERIAL NO.
EFFECTIVITY
DO NOT SCALE DRAWING
The Draftboard Inc

DRAWING NUMBER
EX-23283
NOT REQUIRED


SECTION A-A
FULL R
11°45' REF
45°
.060-80 NF-2B THRU - ITEM 4
.061/.062 DIA THRU & C'SK 82° TO .092/.094 DIA
IN ITEM 3 2 PLACES
.332/.328 DIA BC
.015/.018
.0305/.0310
A .002
-A-
.031 DIA REF
.125/.120
-5 PIN
NOTE: MAKE FROM .031 DIA DRILL ROD
.092/.090 DIA
-3 SCREW
NOTE: MAKE FROM 0-80 F.H. SCREW
2 84830 CL-008A-3 SPRING 5
1 EX23268-3 DRIVE RATCHET 4
1 EX23268-1 DRIVE RATCHET 3
1 -5 PIN 2
2 -3 SCREW 1
LIST OF PARTS
PART CLASS UNCLASSIFIED
DWG CLASS UNCLASSIFIED
UNLESS OTHERWISE SPECIFIED
AVCO SYSTEMS DIVISION
RATCHET ASSY
D 04614 EX23284
DO NOT SCALE DRAWING

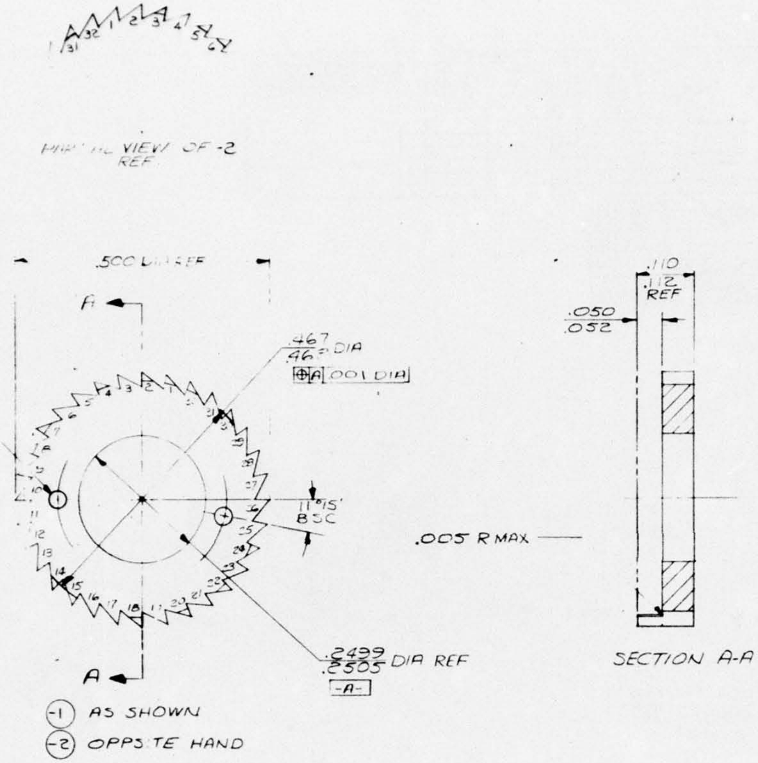
AD-A032 575 AVCO SYSTEMS DIV WILMINGTON MASS F/G 20/6
SWITCH DRIVER CONCEPT DEVELOPMENT.(U)
NOV 76 M E WOLF DAAA21-76-C-0203
UNCLASSIFIED AVSD-0318-76-RR NL

2 OF 2
AD
A032575



END
DATE
FILMED
1-77

NOTES
1. MAKE 1 - ... EX23...S1-3 RATCHET
2. REMOVE BOSSES PER TABLE I, -2 SAME AS -1 EX... OPPOSITE HAND



(-1) AS SHOWN
(-2) OPPOSITE HAND

TABLE I (2)

DASH NO	REMOVE BOSSES FROM THE FOLLOWING TEETH TO DEPTH SHOWN																	
-1	3	5	6	9	11	12	13	16	17	19	21	23	25	26	27	28	29	31
-2	1	2	4	7	8	10	14	15	18	20	22	24	30	32				

SEE TABLE I

LIST OF PARTS

DASH NO.	NEXT ASSY	USED ON	QTY PER ASSY
-2	LA23246	SD	1
-1	LA23246	SD	1

UNLESS OTHERWISE SPECIFIED

AVCO SYSTEMS DIVISION

TITLE LOCK, RATCHET

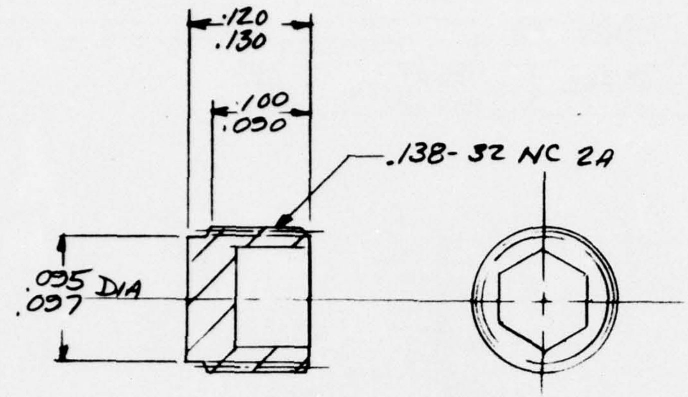
D 04614 EX23285

NOTE
(1) MAKE FROM ALLEN SET SCREW

DRAWING NUMBER	REV

REVISIONS

ENGR CHG	LTR	DESCRIPTION	DATE	APPROVED



/	(1)	
PART OR IDENTIFYING NO.	MATERIAL OR NOTE	SPECIFICATION

LIST OF PARTS

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-1	LA23216	SD	1		
	APPLICATION			EFFECTIVITY	

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
.X ±.08 .XX ±.04 .XXX ±.020
MACHINED ANGLES ±0° 30'
SHEET METAL BEND ANGLES ±2°
P10001 ______
SURFACE ROUGHNESS √

CONTR NO.	
RELEASE	
DWG APPD	
CHECKED	[illegible]
DRAWN	[illegible]
DESIGN APPROVAL	
MANAGER	
SECT CH	
DESIGNER	

AVCO MSD / WILMINGTON, MASSACHUSETTS

TITLE: RESET PLUG

SIZE	CODE IDENT NO.	DWG NO.
B	04614	EX-23286
SCALE 10/1	WT	SHEET

DO NOT SCALE DRAWING

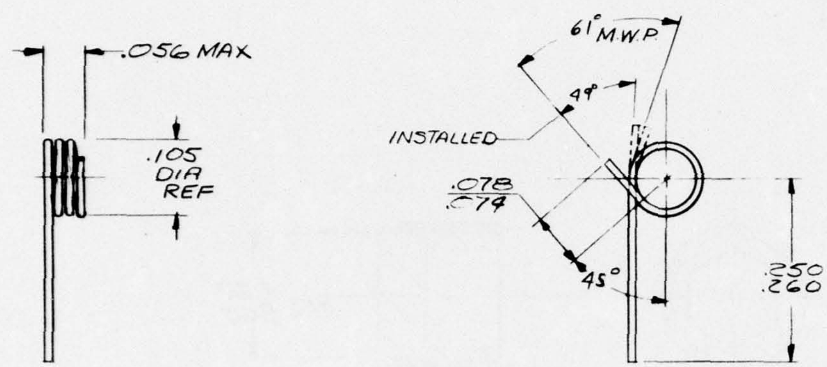


TABLE I	
DASH NO	MAKE FROM LEE SPRING P/N
-1	LT-012A-1L
-2	LT-012A-1R

REVISIONS

ENGR CHG	ZONE	LTR	DESCRIPTION	DATE	APPROVED

LIST OF PARTS

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	SPECIFICATION	ZONE	ITEM NO.
		SEE TABLE I					

ASSY NO.

DASH NO.	NEXT ASSY	USED ON	QTY PER NHA	END ITEM NUMBER	SERIAL NO.
-2	LA23216	SD	1		
-1	LA23216	SD	1		

APPLICATION — EFFECTIVITY

PART CLASS: UNCLASSIFIED
DWG CLASS: UNCLASSIFIED
ABS BY: [signature] 9/4/76

UNLESS OTHERWISE SPECIFIED
TOLERANCE AND DRAWING INTERPRETATION PER D143
X ± .08 XX ± .04 XXX ± .020
MACHINED ANGLES ± 0° 30'
SHEET METAL BEND ANGLES ± 2°
P10001 -40
SURFACE ROUGHNESS √

CONTR NO
RELEASE
DWG APPD
CHECKED [signature] 9/14/76
DRAWN [signature] 9/14/76
DESIGN APPROVAL
MANAGER
SECT CH
DESIGNER

AVCO SYSTEMS DIVISION WILMINGTON, MASSACHUSETTS 01887

TITLE SPRING

SIZE	CODE IDENT NO	DWG NO.
C	04614	EX23287

SCALE 10/1 WT SHEET

DO NOT SCALE DRAWING

EX23287

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